



Daily report

21-05-2020

## Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

## Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓  $a$ : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓  $K$ : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

Martí Català  
Pere-Joan Cardona, PhD  
*Comparative Medicine and Bioimage Centre of  
Catalonia; Institute for Health Science Research  
Germans Trias i Pujol*

Raquel Pérez-Arnal  
Dario Garcia-Gasulla  
Sergio Alvarez-Napagao  
*Barcelona Supercomputing Center*

Clara Prats, PhD  
Sergio Alonso, PhD  
Enric Álvarez, PhD  
Miquel Marchena  
David Conesa  
Daniel López, PhD  
*Computational Biology and Complex Systems;  
Universitat Politècnica de Catalunya - BarcelonaTech*

**With the collaboration of:** Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

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## **(0) Executive summary – Dashboard**

## Global EU+EFTA+UK trends and needs

Globally, the situation in EU+EFTA+UK is good. **Last 7 days, the average number of new daily cases has been 7,238**, a value that takes us to March 14 at the beginning of the pandemic in Europe. Short-term predictions point to a decrease to the level of 5,000 daily new cases the next week.

Observing the values of the estimated index  $EPG_{EST}$  ( $p_7$  multiplied by estimated  $A_{14}$ ) there are **two countries that must be outlined: Sweden, with an  $EPG_{EST}$  of 964, and United Kingdom, with and  $EPG_{EST}$  of 829**. They are, right now,

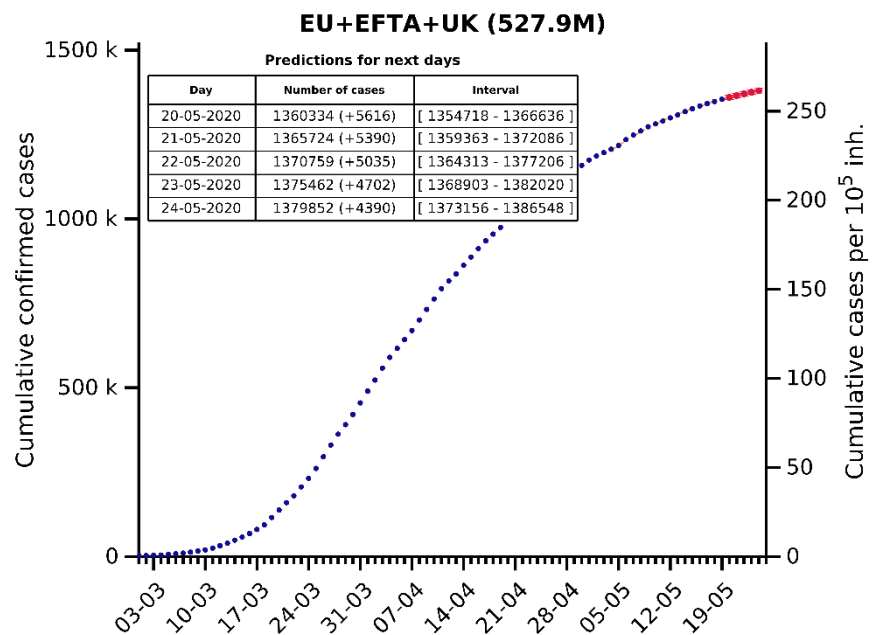
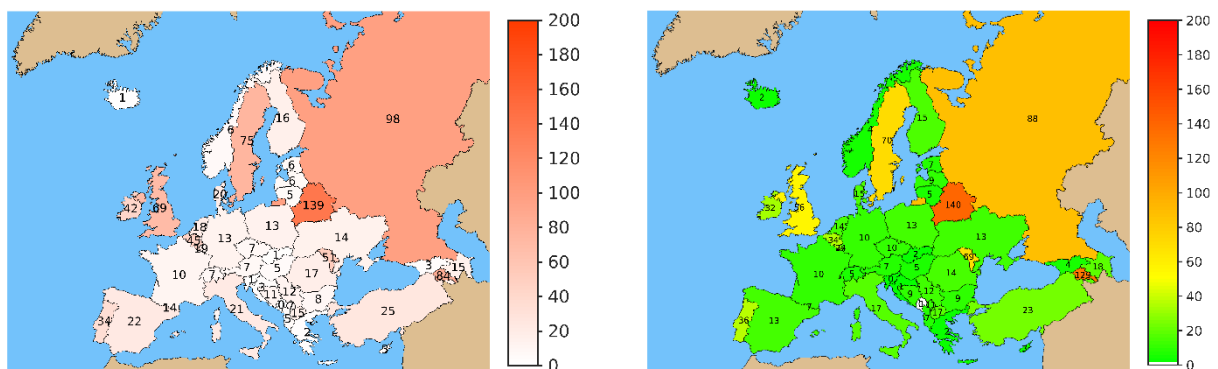
the countries in a more complicated situation. Sweden does not seem to be improving, maintaining a number of about 540 new cases on average daily. However, the UK has shown a clear decrease in new cases over the last two days. On May 20 the number of new cases in this country was 2,412, a level not reached since March 30. It seems that the UK has finally started the decline in the number of new infections.

The analysis is a continuation of last two days, focused on **comparing two mobility indices: one provided by Facebook Data for Good and the other supplied by Google**. This analysis has been elaborated together with researchers from the Barcelona Supercomputing Center.

### Trends for specific countries

There are still several countries with a  $p_7 \geq 1$  but low  $A_{14}$ . Therefore, they remain at low risk. Looking at  $EPG_{REP}$ , all countries but **UK** and **Sweden** are at the green zone (under control).

The map in the left shows current  $A_{14}$ . The map in the right shows current  $EPG$ .



## Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. Last column ( $EPG_{EST}$ ) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details).  $EPG_{REP}$  is calculated with **data reported by countries**.  $EPG_{REP}$  and  $EPG_{EST}$  **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 <sup>5</sup> inh.	Cumulative deaths	Mortality /10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate /10 <sup>5</sup> inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
United Kingdom	248,293	373.7	35,704	53.7	47,092	70.9	0.80	57	829
Spain	232,555	501.8	27,888	60.2	10,510	22.7	0.59	13	160
Italy	227,364	382.6	32,330	54.4	12,907	21.7	0.78	17	240
Germany	176,752	215.8	8,147	9.9	10,661	13.0	0.82	11	51
France	143,845	222.3	28,132	43.5	6,695	10.3	0.95	10	224
Belgium	55,983	492.9	9,150	80.6	5,202	45.8	0.76	35	559
Netherlands	44,447	261.7	5,748	33.8	3,128	18.4	0.75	14	176
Sweden	31,523	320.4	3,831	38.9	7,605	77.3	0.93	72	964
Switzerland	30,575	356.8	1,629	19.0	598	7.0	0.74	5	27
Portugal	29,660	286.0	1,263	12.2	3,478	33.5	1.06	35	158
Ireland	24,315	514.5	1,571	33.2	2,067	43.7	0.77	34	220
Poland	19,739	51.6	962	2.5	4,999	13.1	1.00	13	76
Romania	17,387	87.9	1,141	5.8	3,280	16.6	0.82	14	97
Austria	16,275	186.8	633	7.3	624	7.2	1.01	7	29
Denmark	11,117	194.6	554	9.7	1,134	19.9	0.75	15	76
Czech Republic	8,721	82.2	304	2.9	747	7.0	1.43	10	38
Norway	8,268	154.0	234	4.4	315	5.9	0.71	4	12
Finland	6,443	117.1	304	5.5	870	15.8	0.95	15	78
Luxembourg	3,971	689.4	109	18.9	120	20.8	1.24	26	67
Hungary	3,641	37.3	473	4.8	491	5.0	1.07	5	78
Greece	2,850	25.5	166	1.5	187	1.7	1.08	2	12
Bulgaria	2,331	32.7	120	1.7	553	7.8	1.14	9	52
Croatia	2,234	53.0	96	2.3	115	2.7	0.32	1	NA
Iceland	1,803	495.0	10	2.7	4	1.1	0.36	0	NA
Estonia	1,794	136.7	64	4.9	81	6.2	1.15	7	NA
Lithuania	1,577	54.2	60	2.1	149	5.1	0.95	5	NA
Slovakia	1,496	27.5	28	0.5	67	1.2	1.31	2	NA
Slovenia	1,468	70.6	105	5.1	20	1.0	0.40	0	3
Latvia	1,016	51.5	21	1.1	116	5.9	1.52	9	NA
Cyprus	922	78.8	17	1.5	39	3.3	0.81	3	NA
Malta	584	136.1	6	1.4	100	23.3	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	0	0.0	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200	2000
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

<sup>(1)</sup>  $\rho_3$  is the average of 7 consecutive  $\rho$ , but can still fluctuate. <sup>(2,3)</sup> EPG stands for Effective Growth Potential.  $EPG_{REP}$  is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_7$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days).  $EPG_{EST}$  is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_7$ .

## Highlights for countries with highest number of reported cases

- ✓ Spain has not updated data to ECDC, today. UK has reported less cumulative cases than yesterday.
- ✓ Germany and France seem to slow down decreasing trend and stabilize at around 400 daily new cases (France) and 600 daily new cases (Germany).
- ✓ Italy follows the trend of previous days.

## Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of  $1/10^5$  inhabitants and an attack rate of  $10/10^5$  inhabitants, and time interval between attack rates of 10 to 100 per  $10^5$  inhabitants (only for countries that have overtaken this threshold).

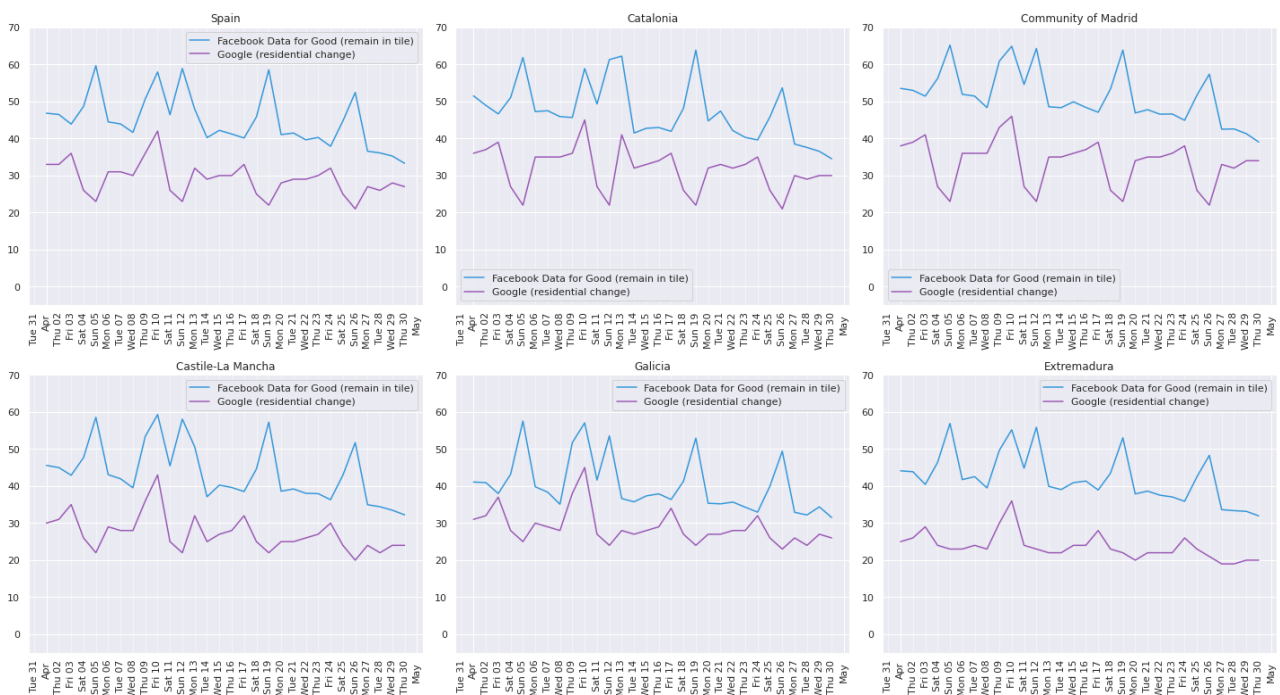
Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / $10^5$ inh. (days)	Time interval between 10 and 100 cases / $10^5$ inh. (days)
Italy	88	11	16
Germany	82	12	17
France	81	10	20
Spain	81	8	12
United Kingdom	77	10	12
Belgium	76	11	14
Netherlands	76	11	20
Sweden	76	10	28
Norway	76	2	7
Switzerland	76	8	11
Austria	74	10	14
Denmark	73	4	30
Czech Republic	70	11	NA
Finland	70	12	46
Greece	70	18	NA
Iceland	70	5	15
Portugal	69	9	15
Slovenia	69	6	NA
Estonia	68	5	30
Ireland	68	8	18
Poland	68	17	NA
Romania	68	15	NA
Luxembourg	65	6	7
Slovakia	64	24	NA
Bulgaria	63	30	NA
Croatia	63	12	NA
Hungary	62	20	NA
Latvia	62	12	NA
Lithuania	61	9	NA
Malta	60	9	35
Cyprus	59	12	NA

## Analysis: Assessments on mobility data on confinement and deconfinement (II).

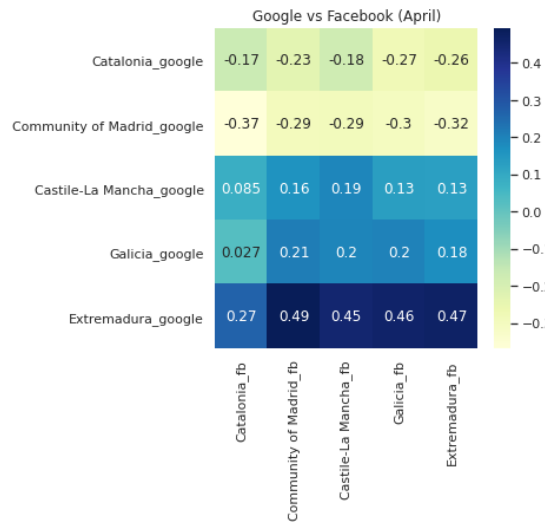
We showed yesterday that both Facebook Data for Good (FDG) and Google (GGL) provide two measurements of confinement which were highly correlated during the process of confinement of Spain. We have detected the same trend in multiple countries, so it is clear that both can measure important changes in confinement.

**We address now if both indexes can provide good quantitative information regarding mobility.** This is, we want to check if they can detect changes in data that are not abrupt and still find similar results. It is important to remember that, since both indexes measure slightly different things, we should require high correlations and not equality. If both indexes produce a highly correlated measurement of confinement, even the very different ways the data is gathered processed and analyzed in both companies, we know that they can be used to quantify the level of confinement. This will make it useful as a proxy for the number of contacts. **The higher its value, the lower the number of contacts.**

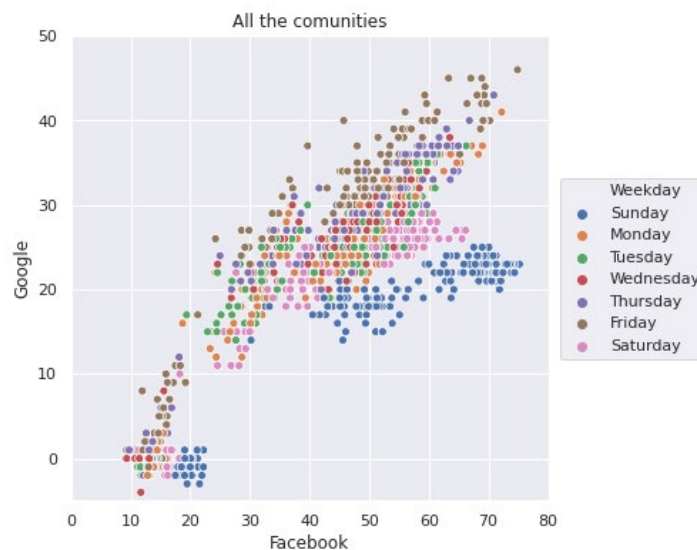
The proper way to address if both measures are quantitatively similar is to **look for relations during periods where changes in confinement were not large.** Here, again, Spain is a very good country to test this possibility. Using April as the month where Spain was under curfew restrictions, we observe that changes in both indexes are not large. We show both indexes again in the same regions we used in the last report: Spain as a whole together with Madrid, Catalunya, Castilla-La Mancha, Galicia and Extremadura.



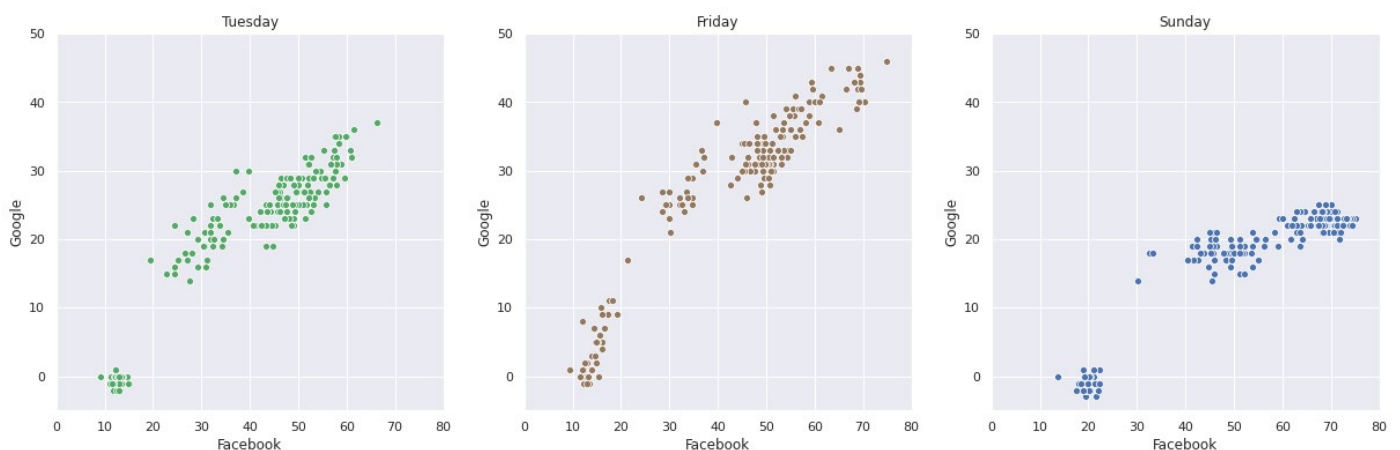
We can now check the correlation between both measures during this period (see figure in next page). We observe that now the correlation is very small and different in sign depending on the region. We are clearly detecting problems in both measurements if we consider them at face value. **The important insight we have uncovered is that the reason for this mismatch and for the apparent unreliability of both measurements is that they effectively measure very different things depending on the day of the week under consideration.** During labor days, most of the deconfinement is related with work and related trips, while during the weekend most is related mainly with leisure or shopping.



If we look at the relation between both indexes in March and April and indicate the **day of the week** we see that the **relation between both is clearly different**. The next figure shows a scatter plot of both indexes for all Spanish regions, with a different color depending on the day of the week.



As suggested by the previous figure, **we can correlate both measurements for a given day and corroborate that correlations are recovered**. Next figures show the cloud of points of both indexes for Tuesdays, Fridays and Sundays, for all Spanish regions. For a typical working day like Monday, correlation is 0.95. However, the correlation for Sunday points 0.92.

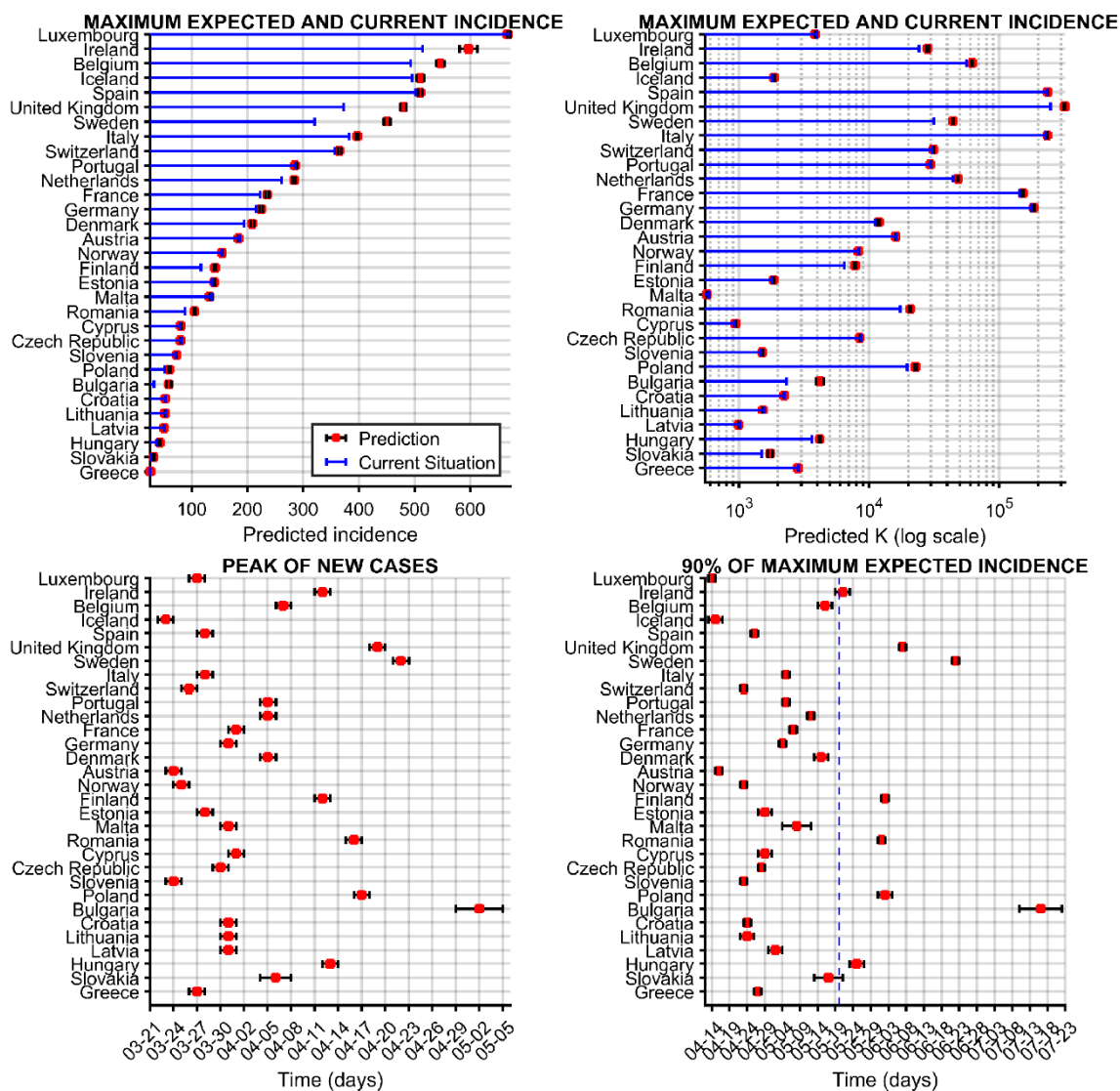


In fact, the differences on Sundays and holidays are tricky to explain. Holidays are easily identified in FDG as an increase in confinement index. See, for instance, the peaks in all Sundays but also in Easter Holidays (Friday 10<sup>th</sup> and Sunday 12<sup>th</sup> April in all regions, and Thursday 9<sup>th</sup> or Monday 13<sup>th</sup> April depending on the region). However, GGL shows either an increase or a decrease on holidays; i.e., it captures a change on people's behavior, but reflect it in a different way.

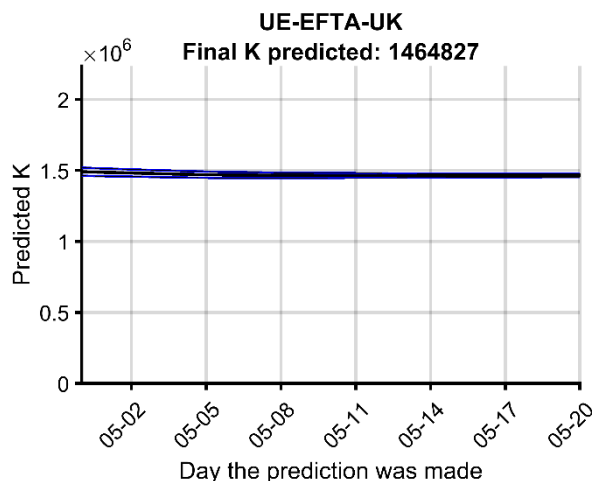
In any case, knowing that both indexes can be related univocally once the day of the week is taken into account, we can develop a single index for confinement provided we know the day of the week we are dealing with. We will address this point in following reports, next week.

## Long-term predictions

**Long-term predictions**, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per  $10^5$  inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.

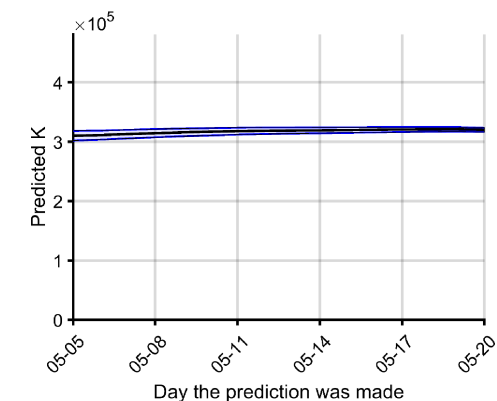
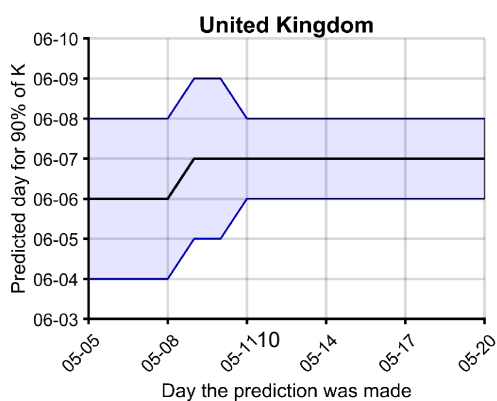
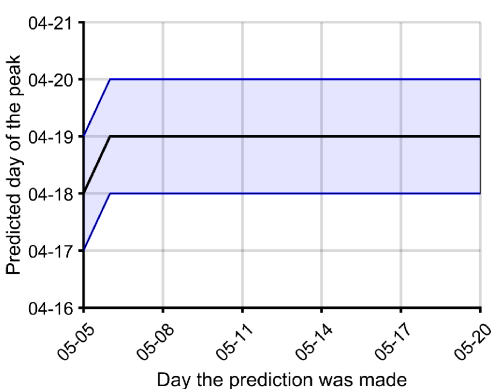
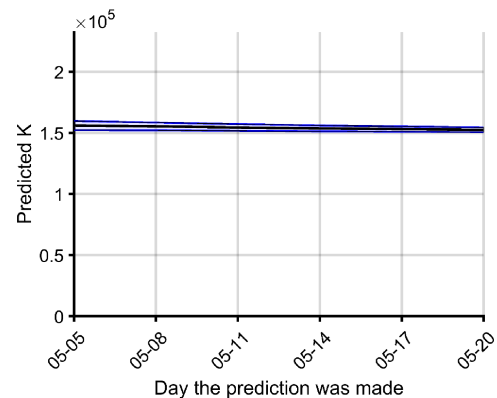
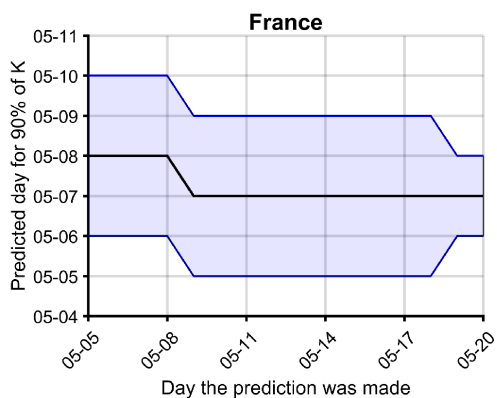
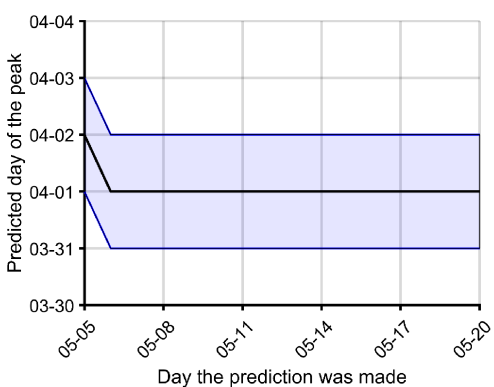
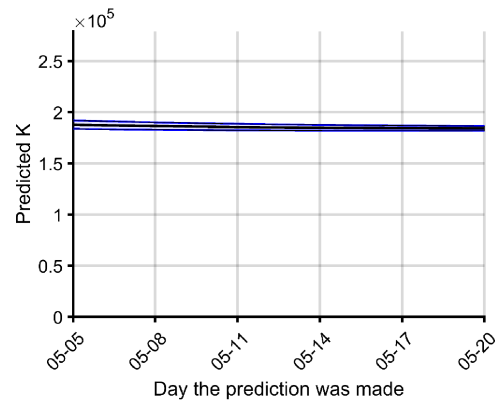
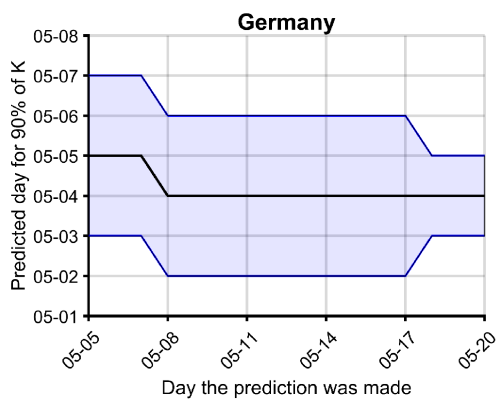
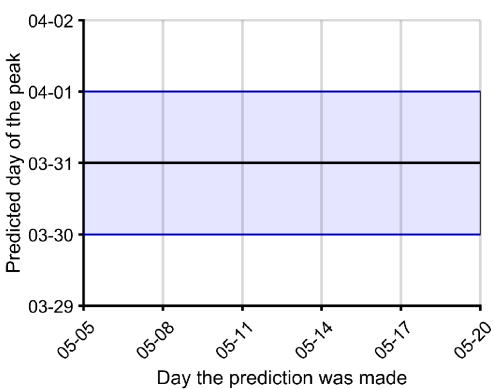
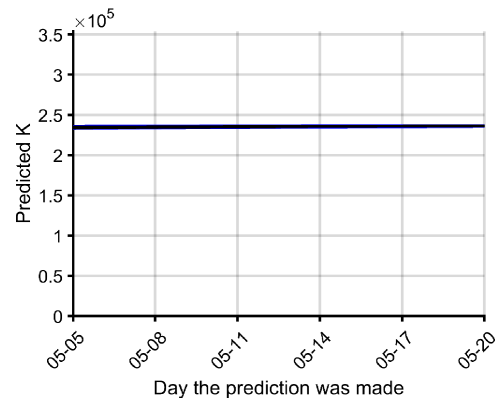
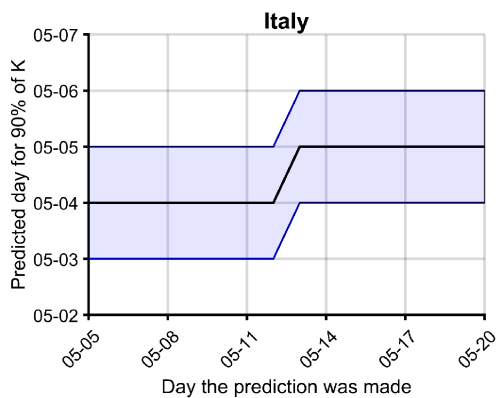
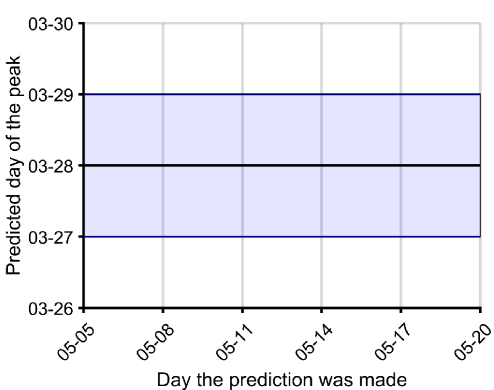
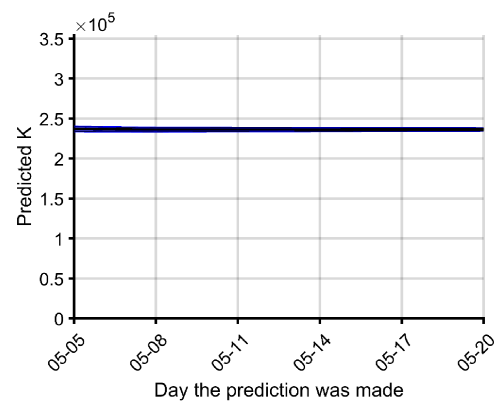
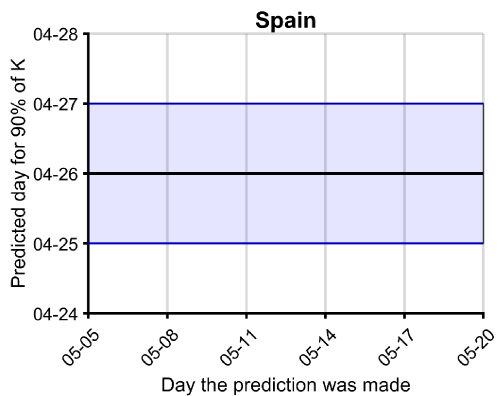
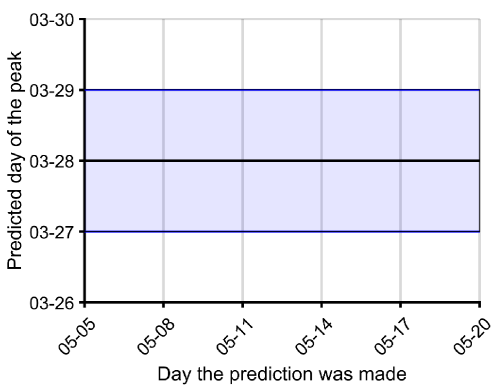


**Final expected K for UE+EFTA+UK.** Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



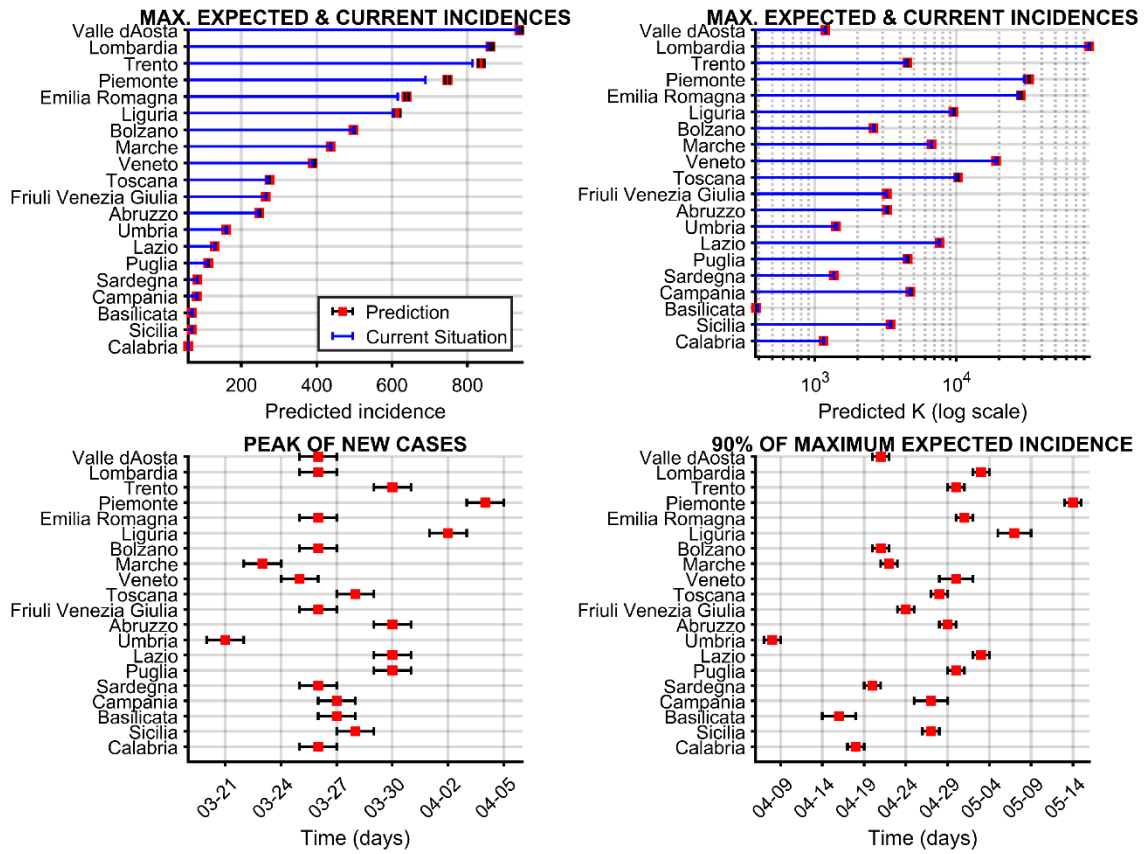


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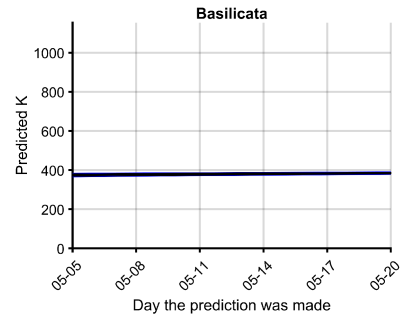
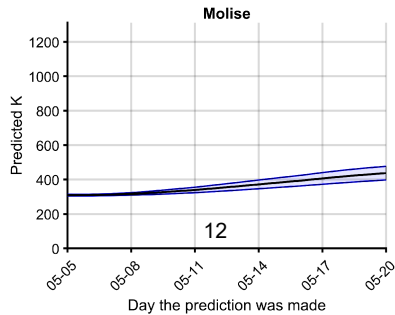
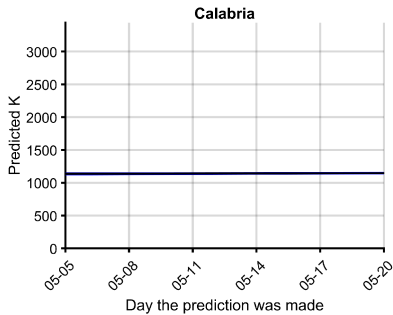
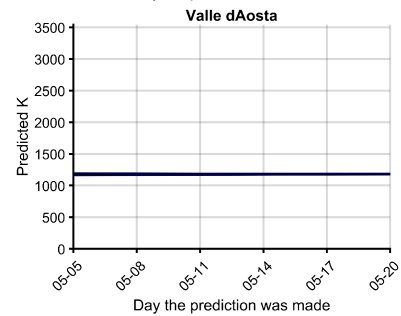
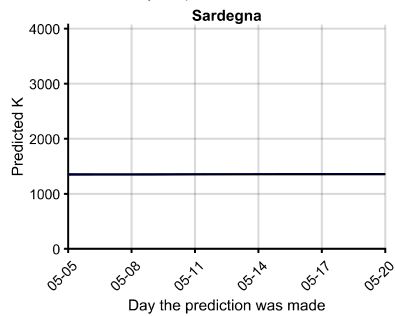
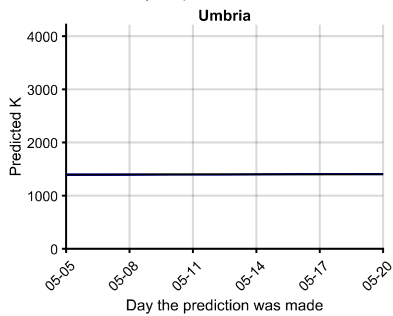
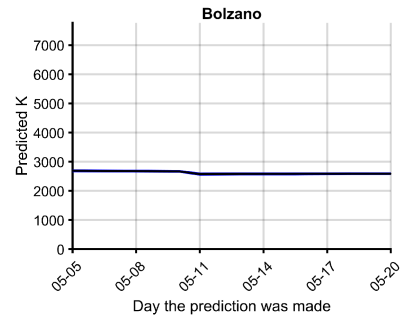
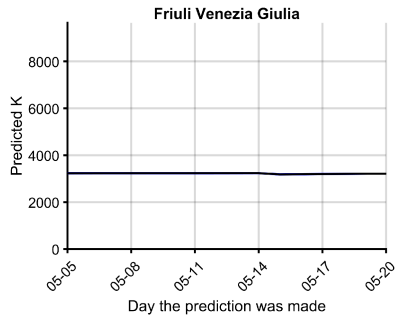
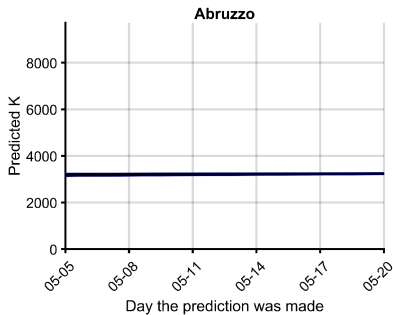
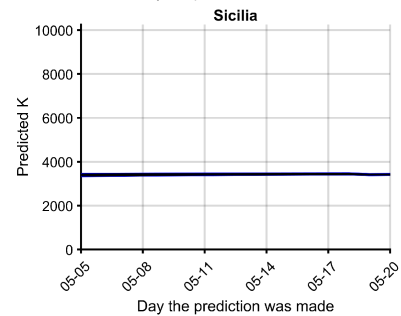
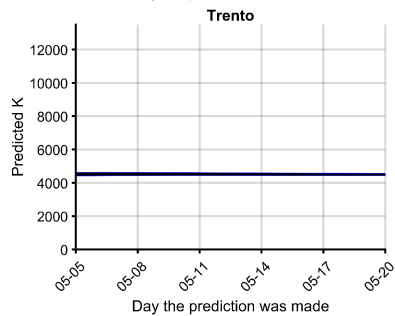
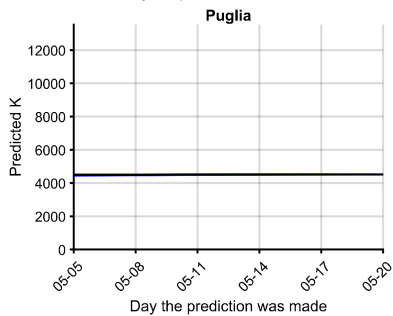
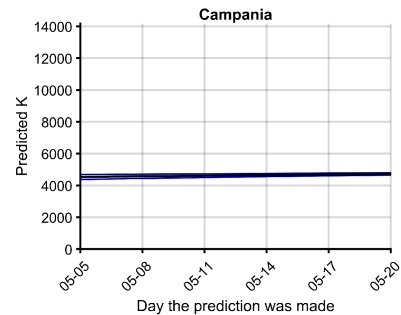
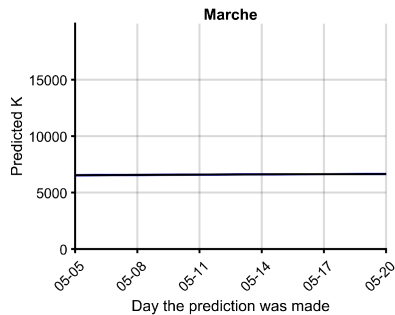
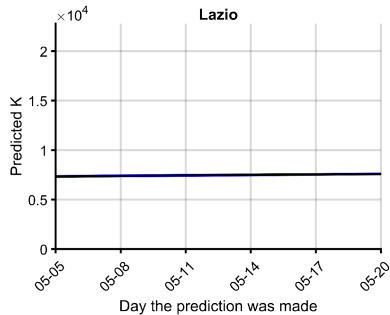
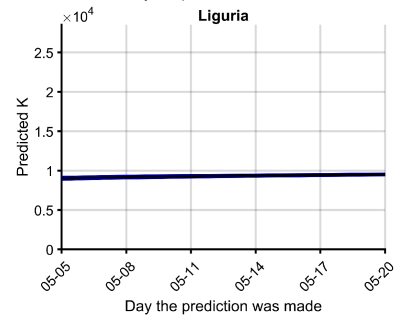
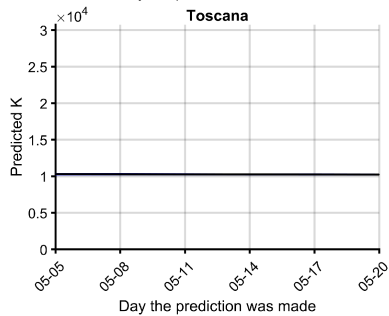
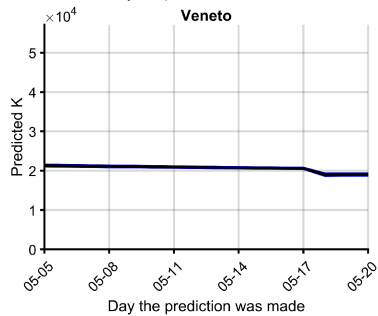
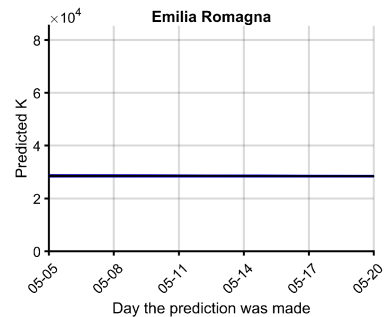
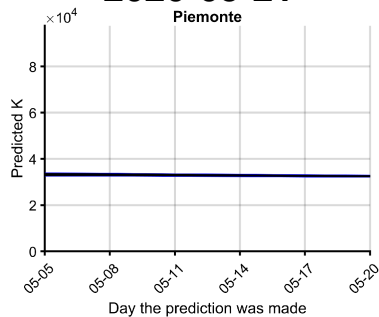
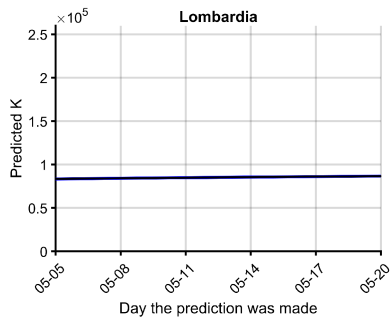


## Italian regions

2020-05-21



2020-05-21



## Situation and trends in Italian and Spanish regions

### Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 <sup>5</sup> inh.	Cumulative deaths	Mortality / 10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate / 10 <sup>5</sup> inh.	$\rho_7^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Lombardia	86,091	857.3	15,727	156.6	6,002	59.8	0.74	44	824
Piemonte	29,990	688.4	3,742	85.9	1,855	42.6	0.82	35	442
Emilia Romagna	27,417	614.8	4,025	90.3	930	20.9	0.74	16	229
Veneto	19,038	388.1	1,841	37.5	485	9.9	0.77	8	75
Toscana	10,000	268.1	1,004	26.9	317	8.5	0.97	8	84
Liguria	9,344	602.6	1,397	90.1	699	45.1	1.10	49	764
Lazio	7,558	128.6	662	11.3	524	8.9	1.16	10	95
Marche	6,689	438.5	990	64.9	237	15.5	0.61	9	143
Campania	4,723	81.4	403	6.9	182	3.1	0.92	3	25
Puglia	4,413	109.5	478	11.9	168	4.2	0.65	3	31
Trento	4,378	408.3	455	42.4	95	8.9	1.74	15	326
Sicilia	3,417	68.3	268	5.4	129	2.6	0.76	2	15
Friuli Venezia Giulia	3,215	264.6	323	26.6	108	8.9	0.96	9	88
Abruzzo	3,212	244.9	391	29.8	140	10.7	1.15	12	158
Bolzano	2,587	2,407.9	291	270.9	35	32.6	0.86	28	65
Umbria	1,429	162.0	74	8.4	24	2.7	0.70	2	NA
Sardegna	1,356	82.7	127	7.7	32	2.0	0.65	1	12
Valle d'Aosta	1,176	936.3	143	113.8	26	20.7	0.71	15	185
Calabria	1,156	59.4	96	4.9	31	1.6	0.79	1	NA
Molise	423	138.4	22	7.2	118	38.6	0.34	13	NA
Basilicata	394	70.0	27	4.8	11	2.0	0.87	2	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200	2000
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

### Spain

Autonomous regions	Cumulative cases	Attack rate / 10 <sup>5</sup> inh.	Cumulated deaths	Mortality rate / 10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate / 10 <sup>5</sup> inh.	$\rho_7^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Madrid	66,860	1,006.8	8,912	134.2	2,079	31.3	0.79	25	333
Catalunya	55,888	738.8	6,021	79.6	NA	NA	NA	NA	NA
Castilla y Leon	18,586	771.8	1,960	81.4	1,066	44.3	0.95	42	448
Castilla-La Mancha	16,739	822.4	2,913	143.1	595	29.2	0.97	28	506
Euskadi	13,435	616.8	1,480	68.0	427	19.6	1.53	30	332
Andalucia	12,502	148.4	1,371	16.3	312	3.7	1.51	6	62
Comunitat Valenciana	10,949	220.1	1,378	27.7	412	8.3	1.08	9	113
Galicia	9,067	335.8	607	22.5	166	6.1	0.54	3	22
Aragon	5,551	420.3	843	63.8	320	24.2	1.18	29	451
Navarra	5,136	790.2	503	77.4	170	26.2	0.54	14	142
La Rioja	4,033	1,286.1	353	112.6	53	16.9	1.27	21	194
Extremadura	3,040	285.3	504	47.3	175	16.4	2.01	33	563
Asturias	2,374	232.2	304	29.7	52	5.1	0.76	4	49
Canarias	2,300	104.2	155	7.0	69	3.1	0.77	2	17
Cantabria	2,277	391.4	209	35.9	64	11.0	0.87	10	88
Baleares	2,018	169.9	221	18.6	99	8.3	2.31	19	228
Murcia	1,560	104.9	148	9.9	62	4.2	1.46	6	59
Melilla	121	142.8	2	2.4	2	2.4	NA	NA	NA
Ceuta	119	140.3	4	4.7	10	11.8	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200	2000
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

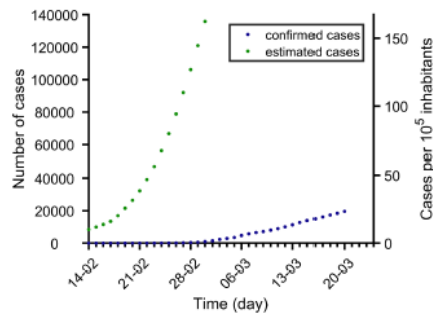
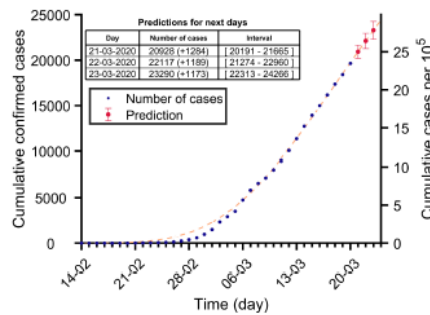
**Warning: indexes from Spanish regions are affected by a new protocol on data reporting. Historical series are still under revision. This may seriously affect the evaluation of  $\rho_7$ ,  $A_{14}$  and EPG.**

<sup>(1)</sup>  $\rho_7$  is the average of 7 consecutive  $\rho$ , but can still fluctuate. <sup>(2,3)</sup> EPG stands for Effective Growth Potential. EPG<sub>REP</sub> is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_7$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG<sub>EST</sub> is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_7$ .

## Legend: Countries' reports details

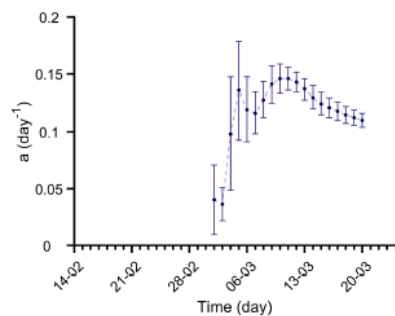
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence:  $23/10^5$

Confirmed cases:  
data (blue),  
model fitted  
(dashed line),  
predictions (red  
points and table)

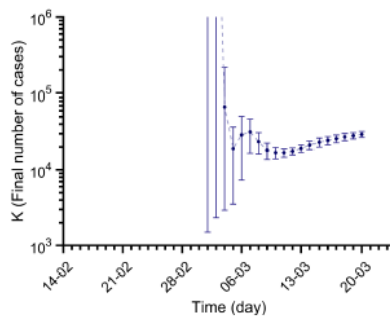


Estimated  
cases using  
death rate (see  
Methods)

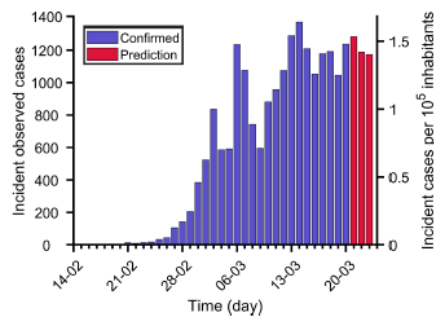
Fitted  $a$  value  
using points  
prior to each  
date



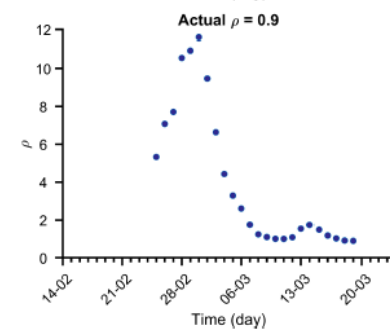
Fitted  $K$  value  
using points  
prior to each  
date



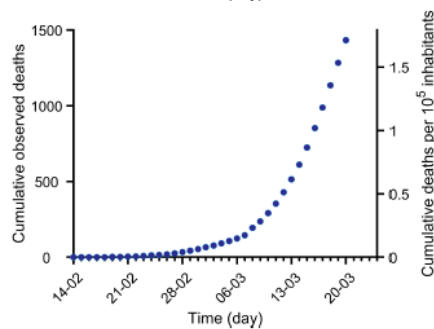
Reported  
and  
predicted  
new cases



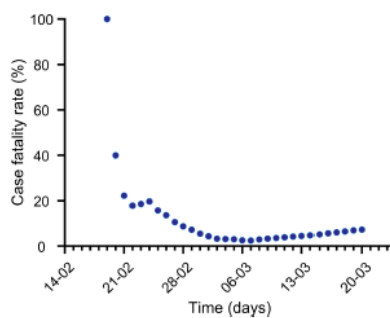
Evolution of  $\rho$ , a  
parameter related  
with Reproduction  
number (see  
Methods)



Reported  
deaths

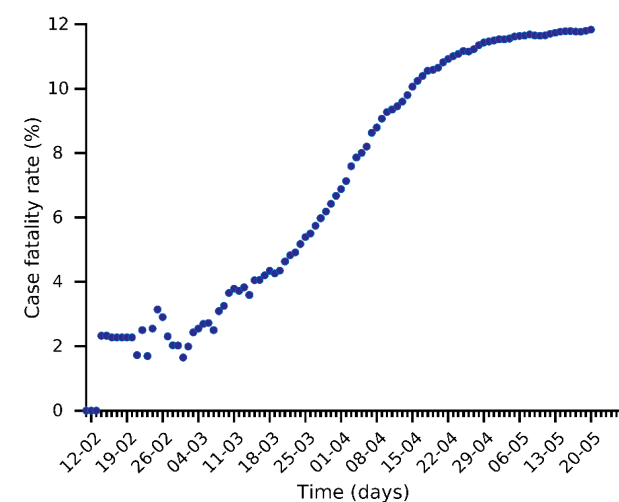
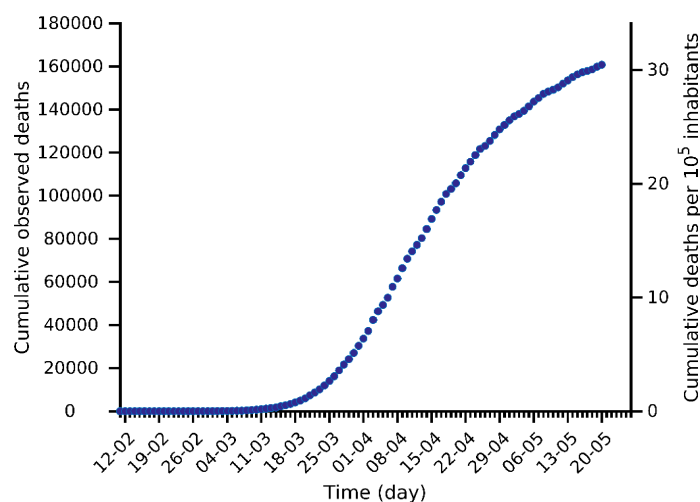
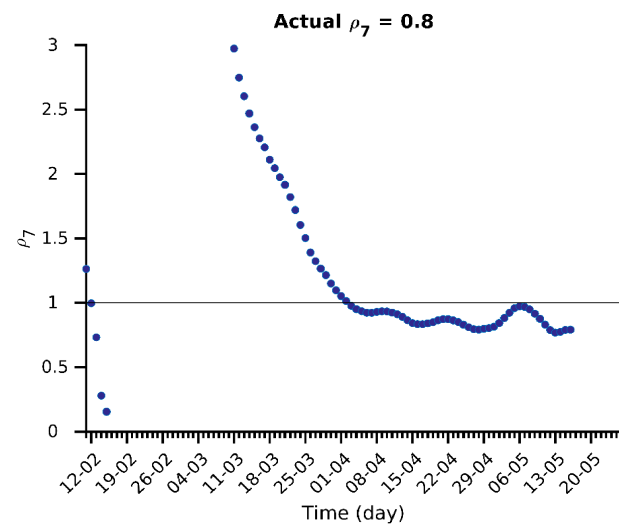
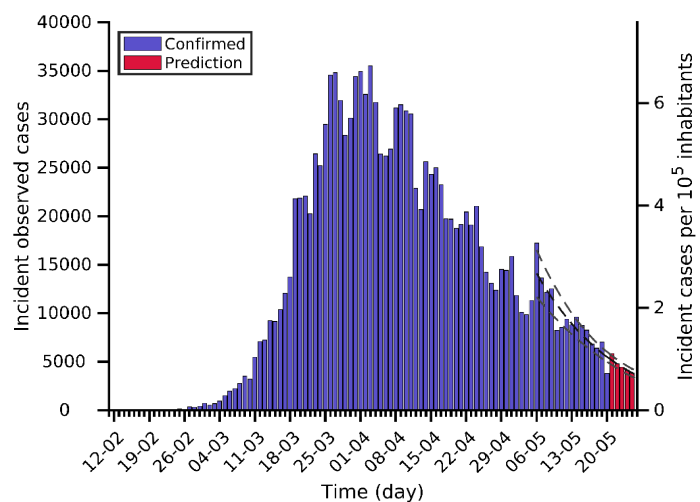
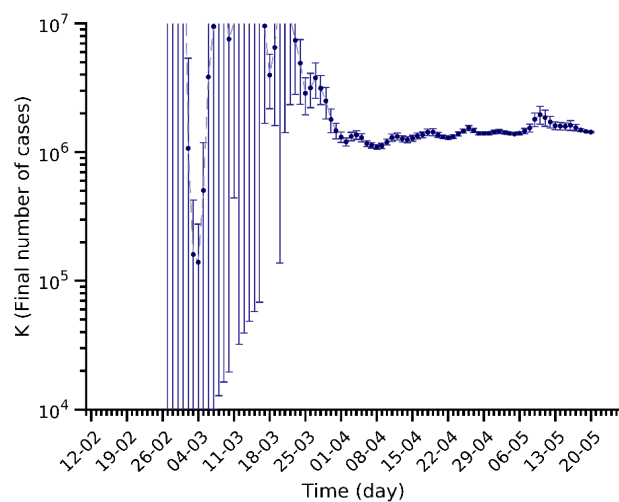
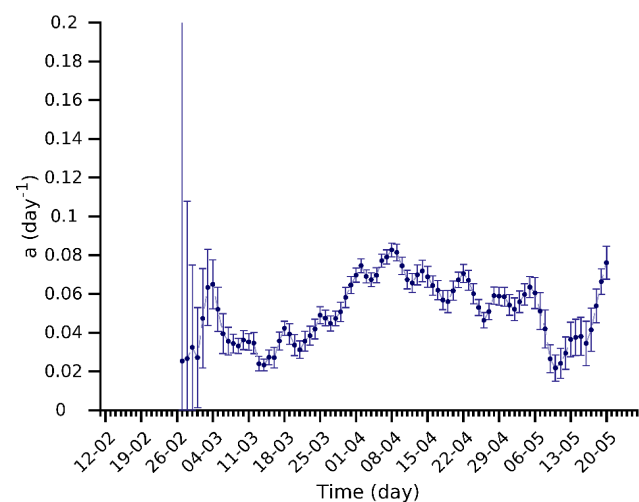
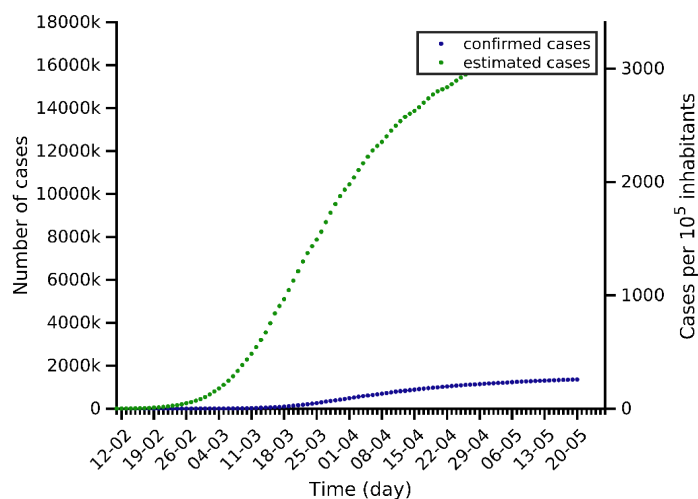
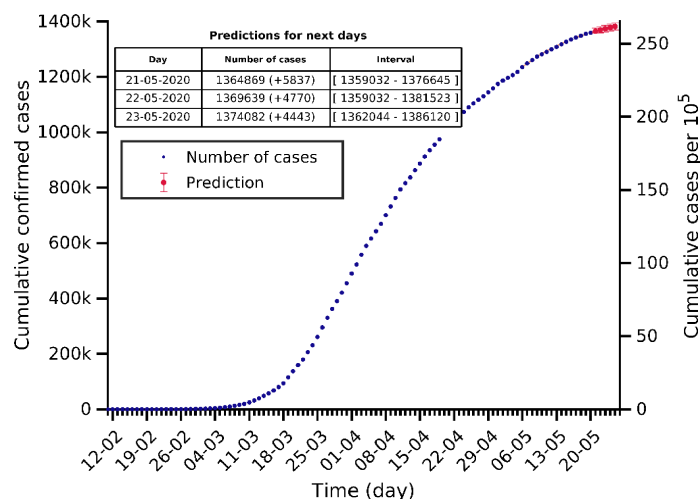


Deaths /  
cumulated  
reported cases

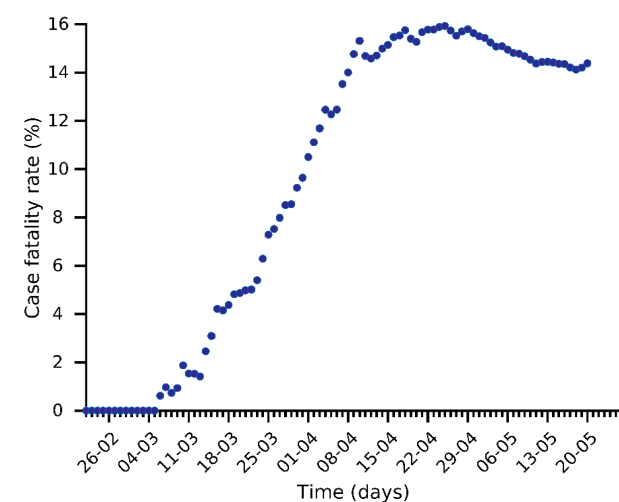
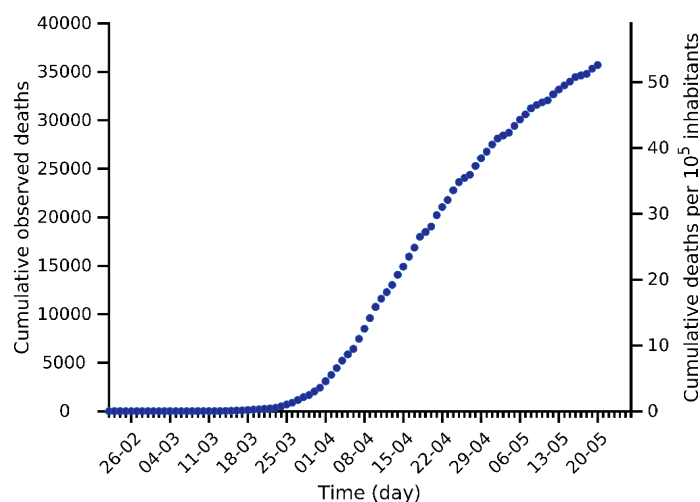
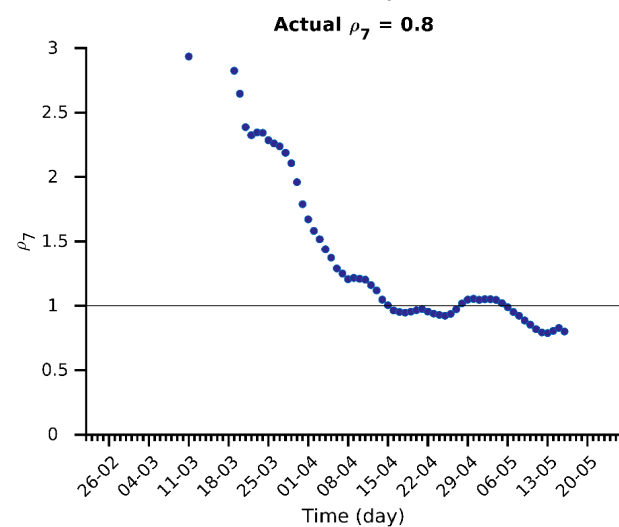
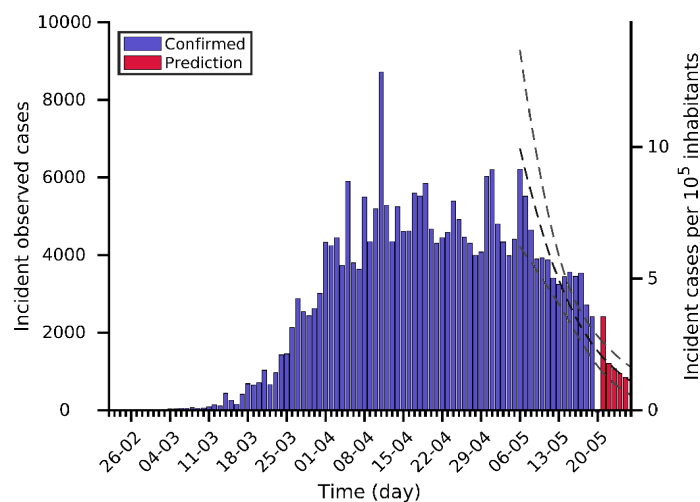
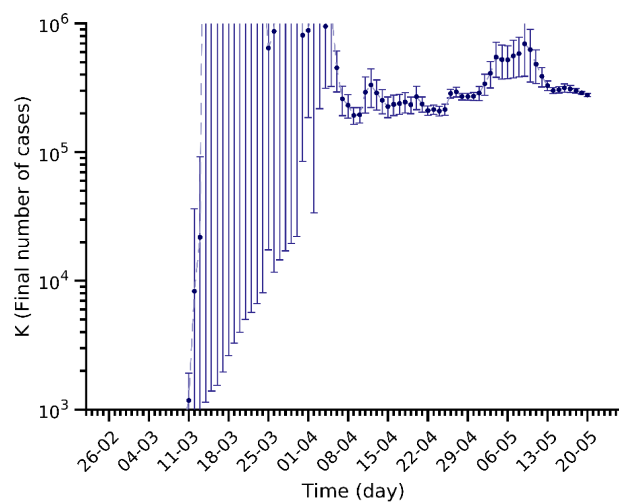
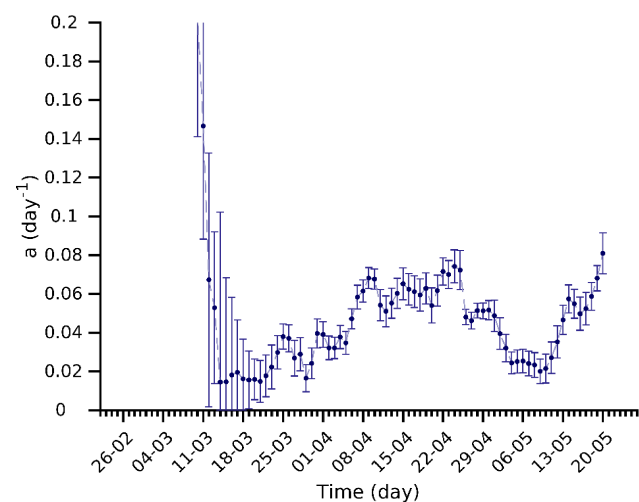
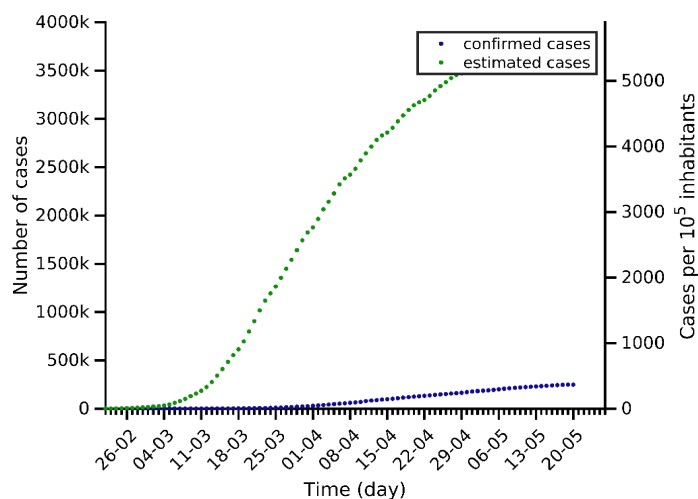
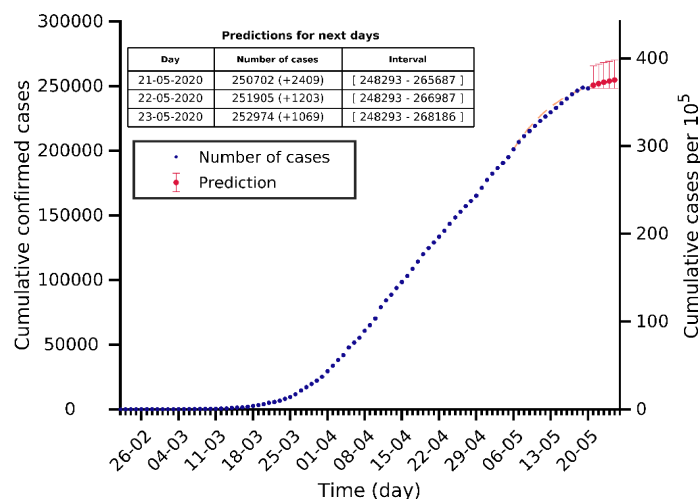


## **(1) Analysis and prediction of COVID-19 for EU+EFTA+UK**

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

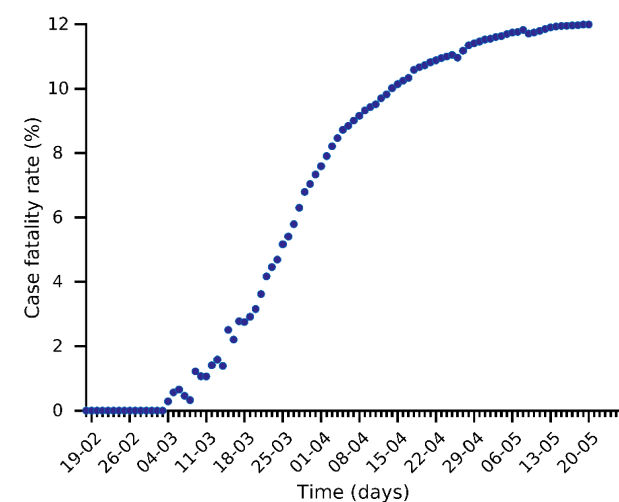
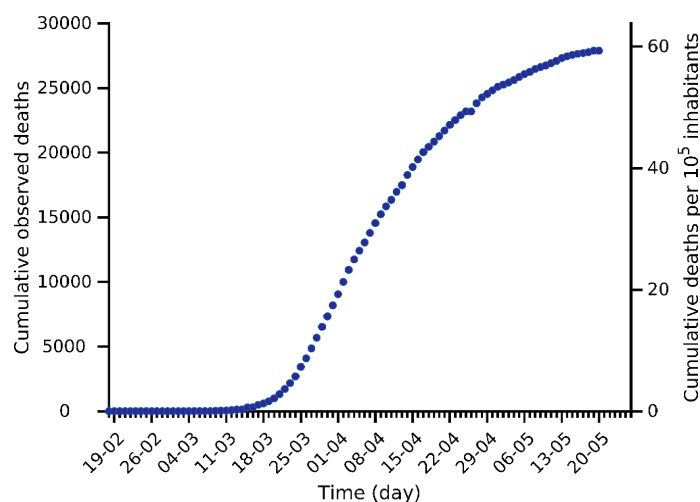
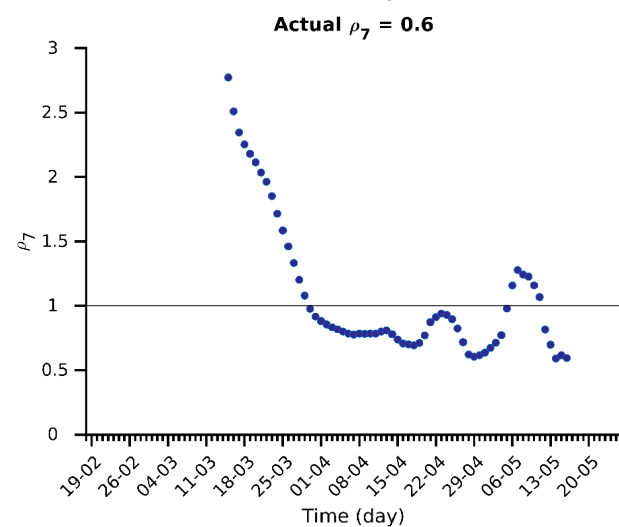
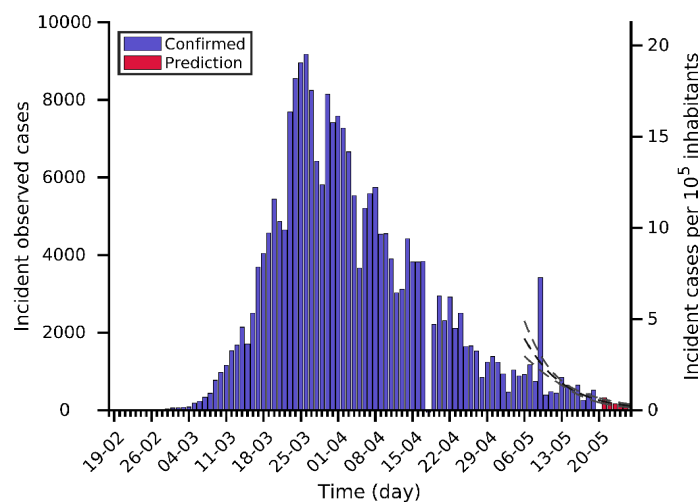
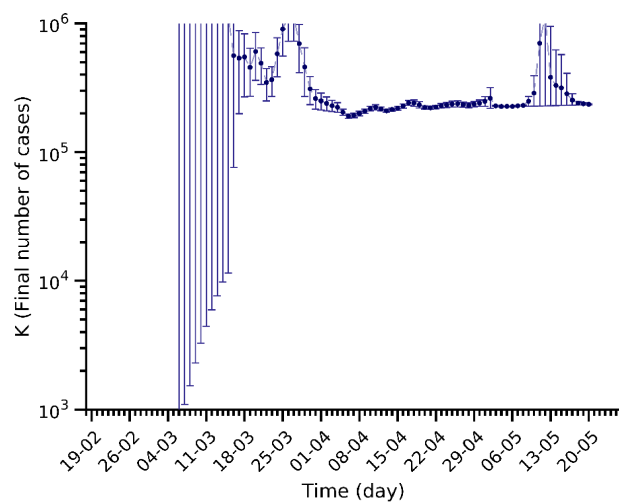
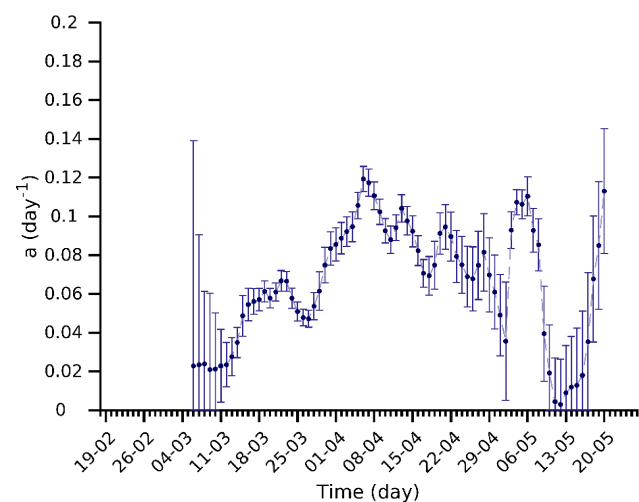
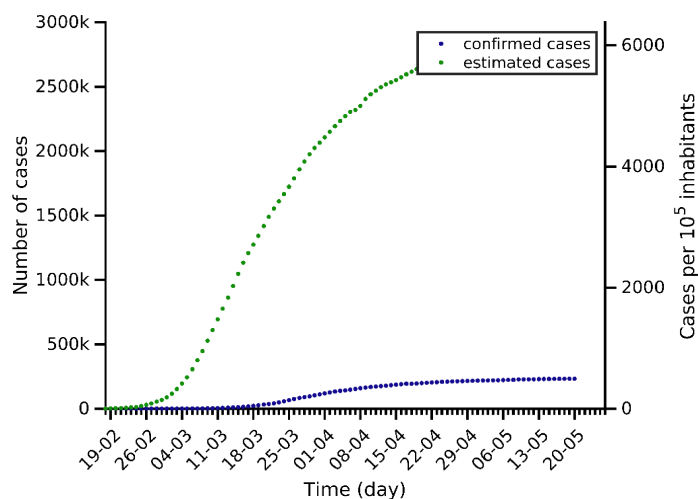
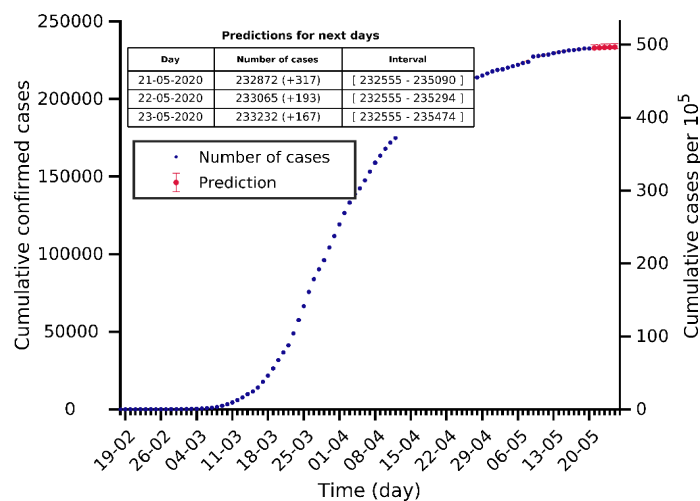


# UK 20-05-2020. Population: 67.9M. Current cumulated incidence: 366/10<sup>5</sup>

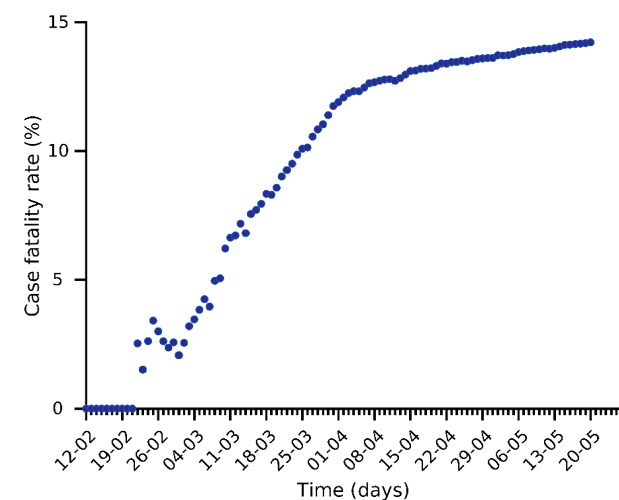
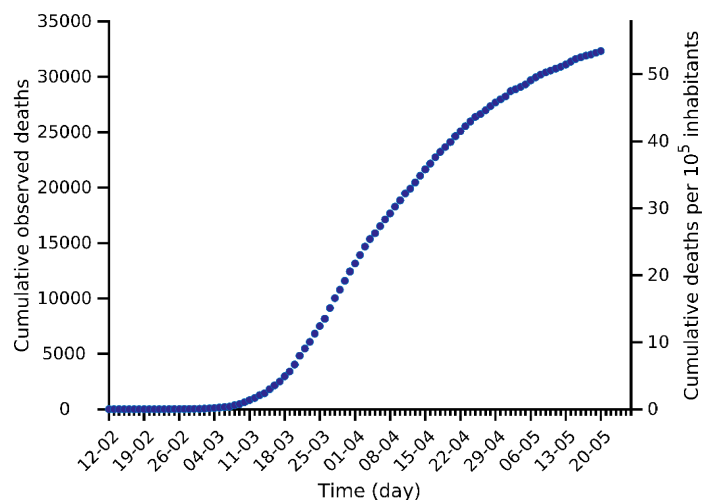
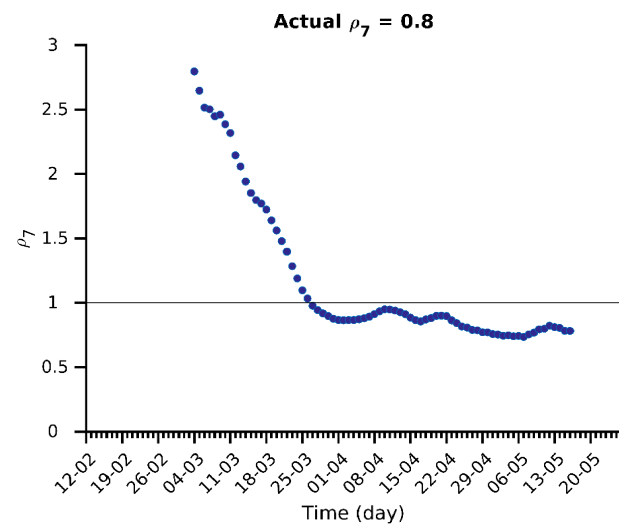
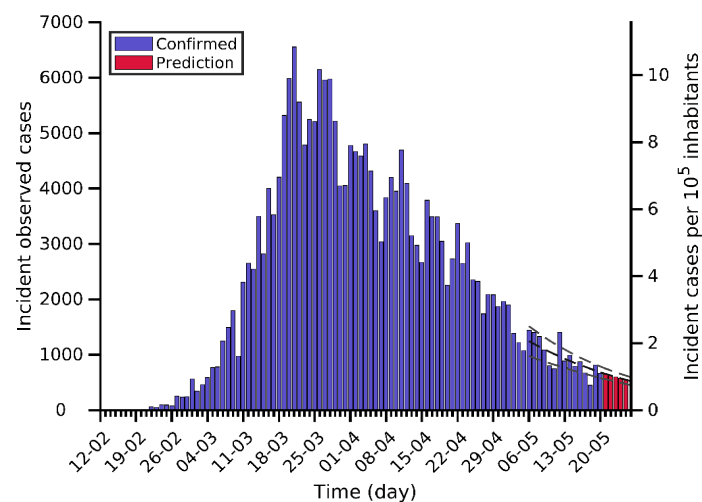
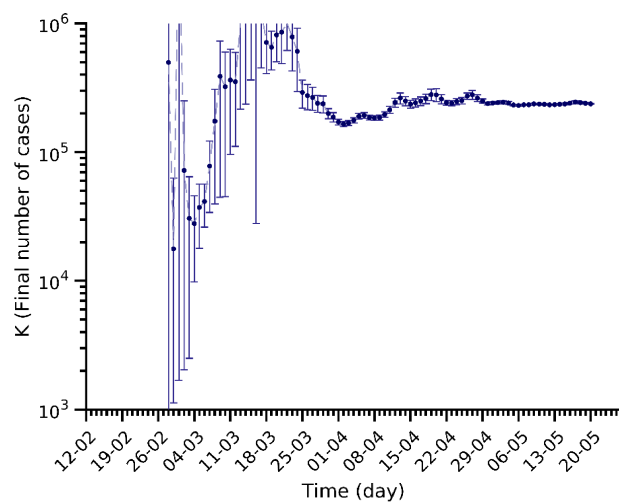
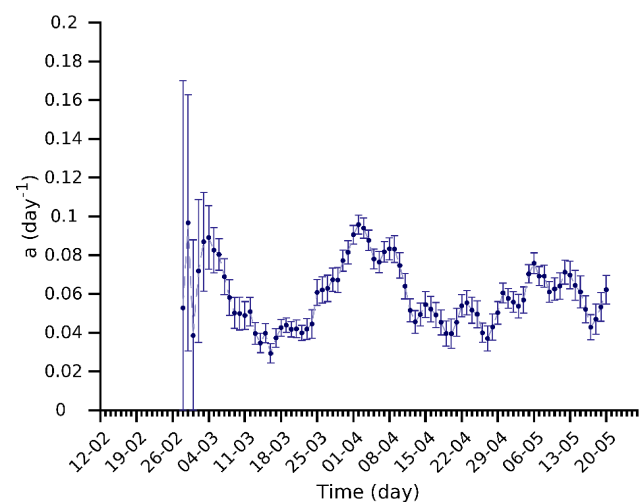
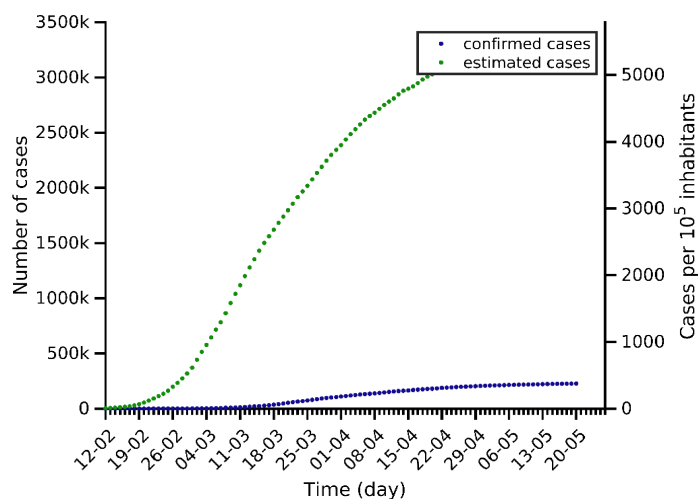
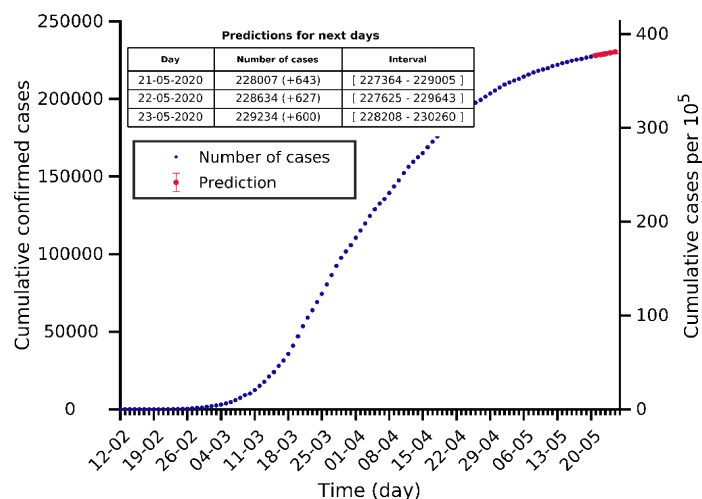




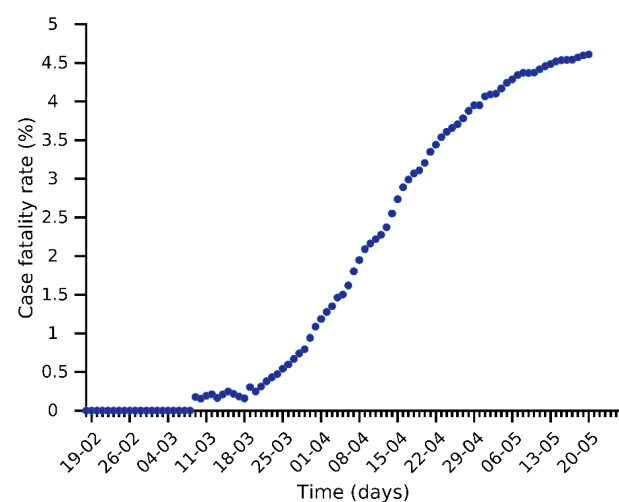
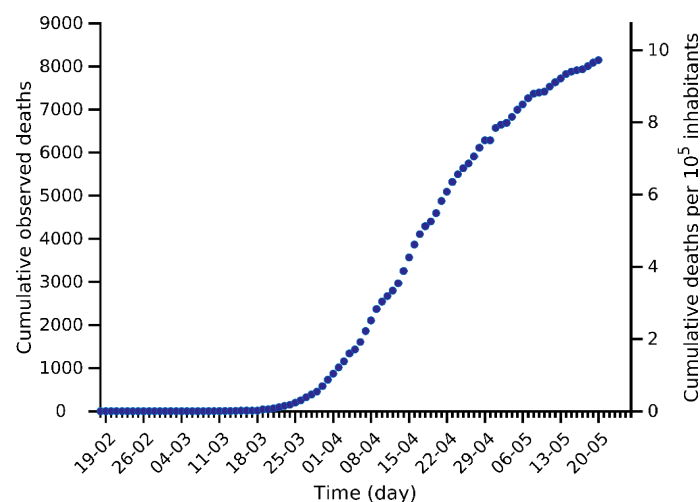
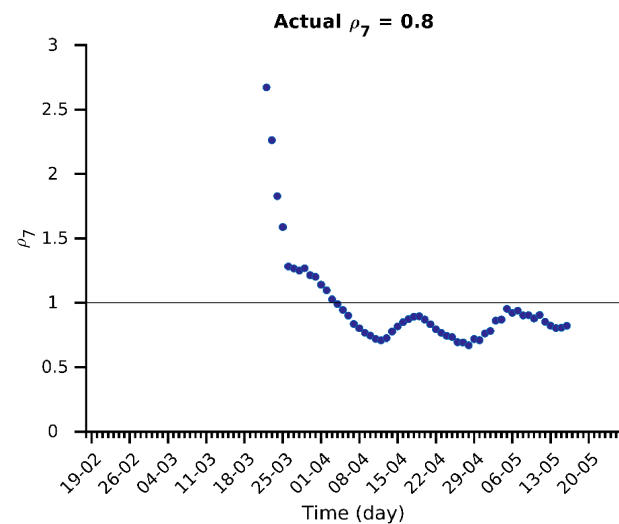
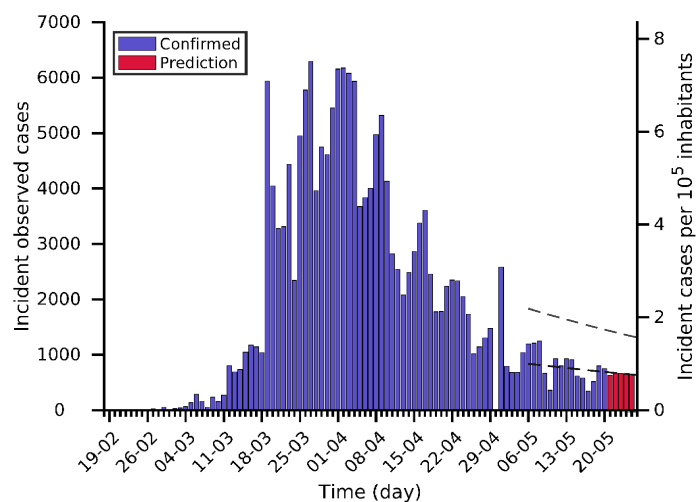
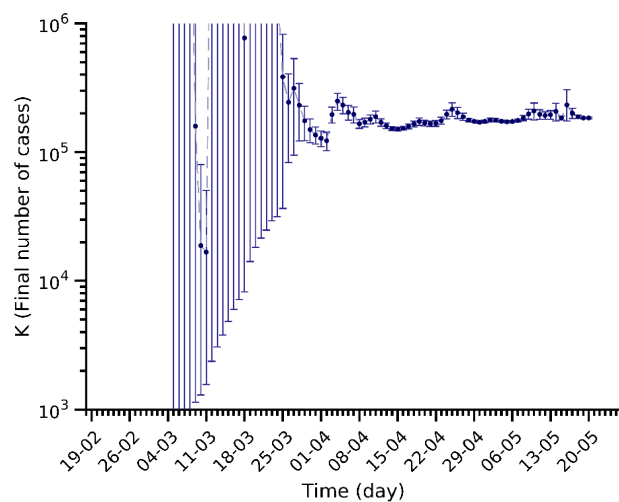
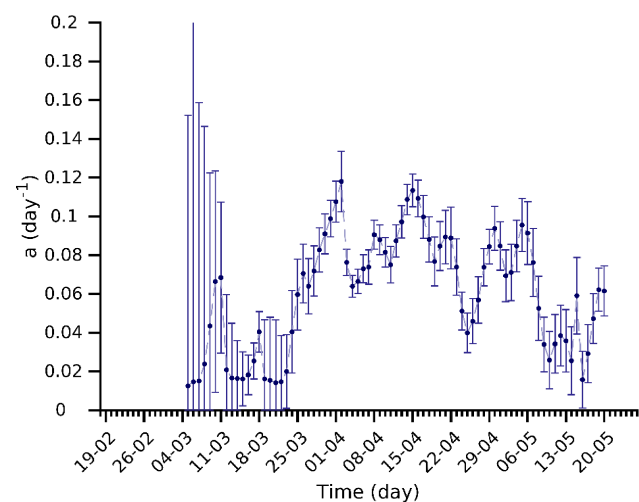
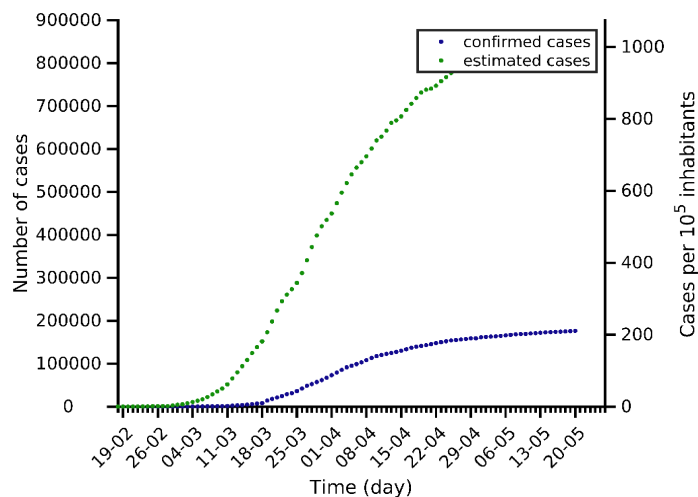
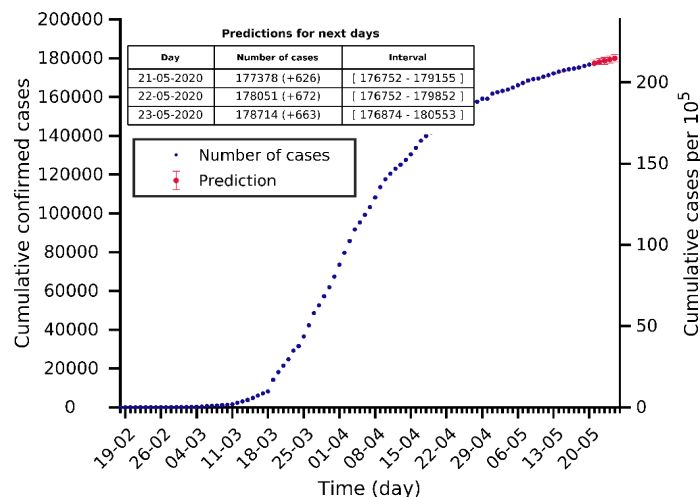
# Spain 20-05-2020. Population: 47.0M. Current cumulated incidence: 495/10<sup>5</sup>



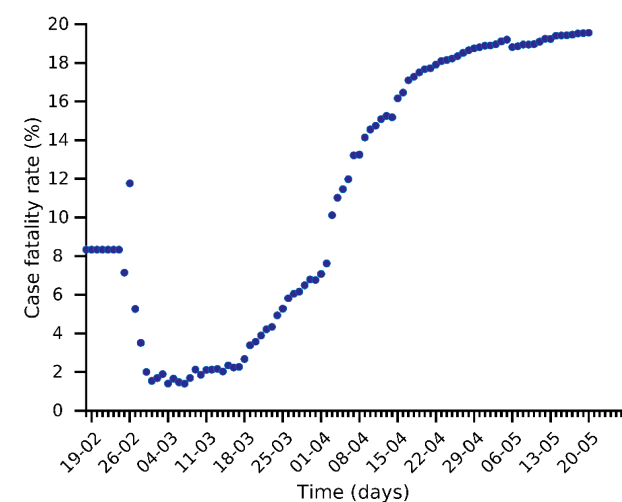
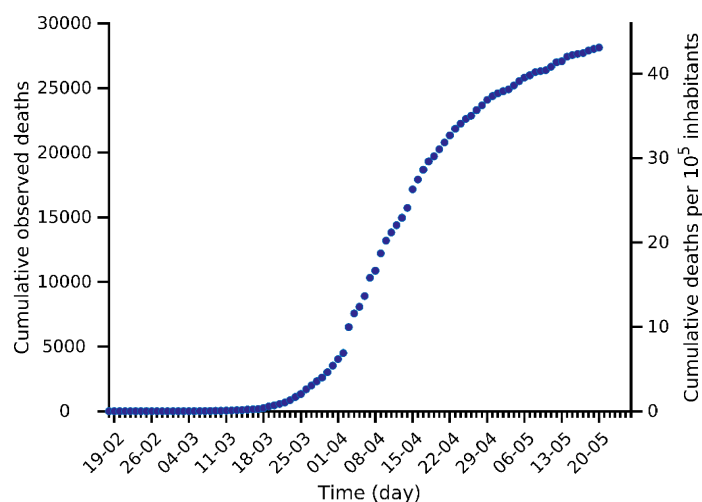
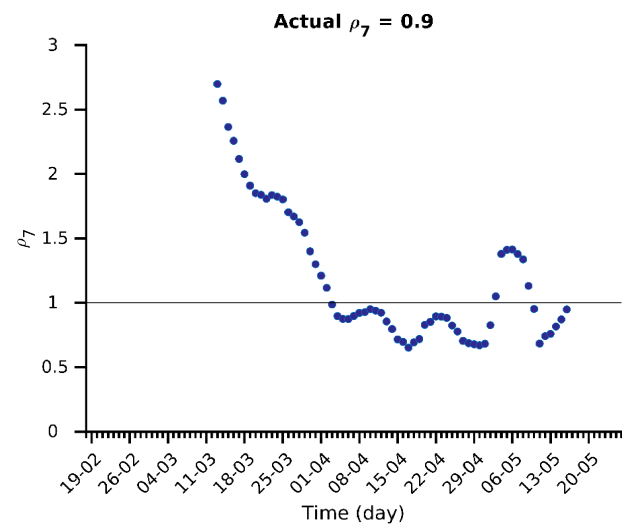
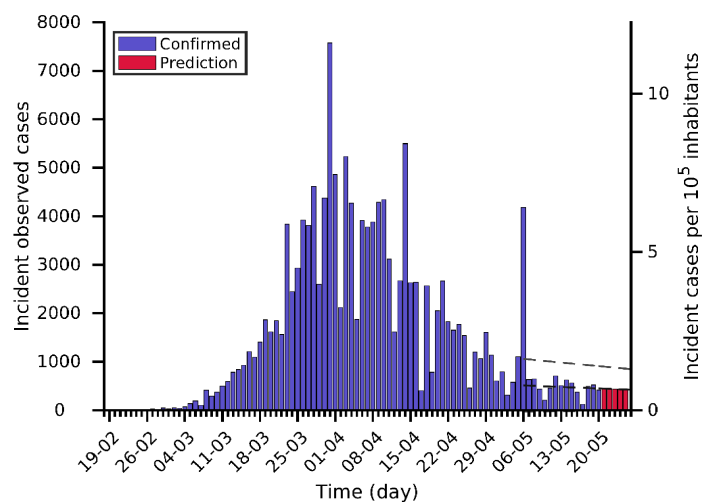
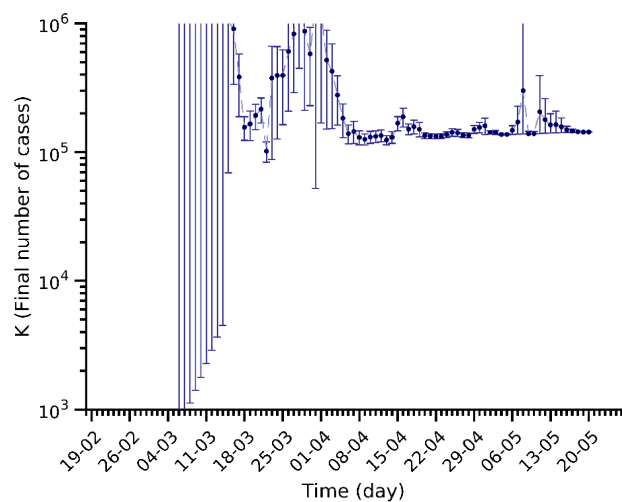
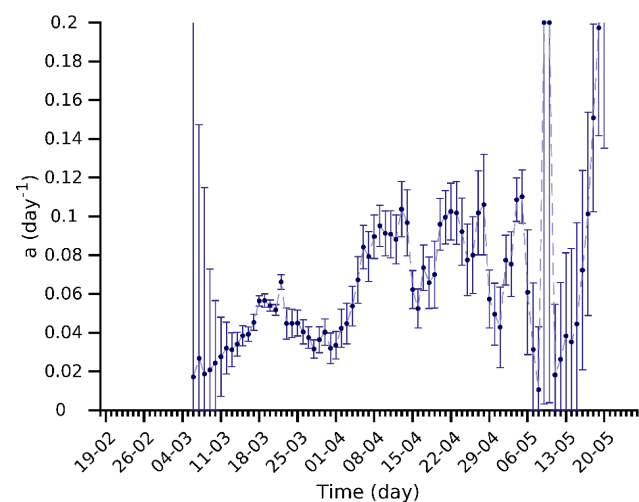
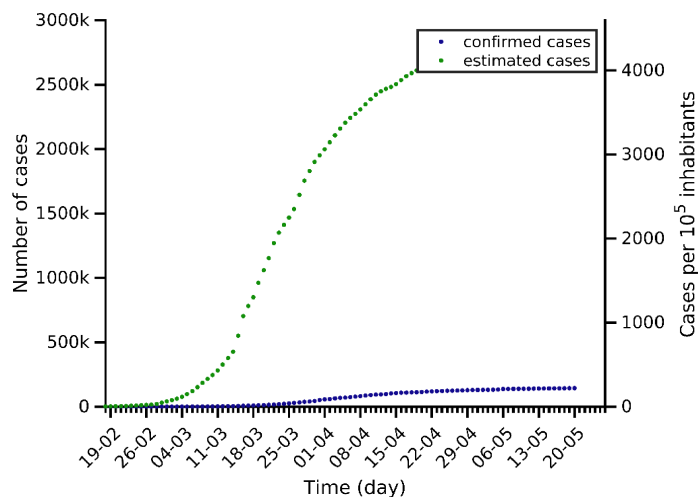
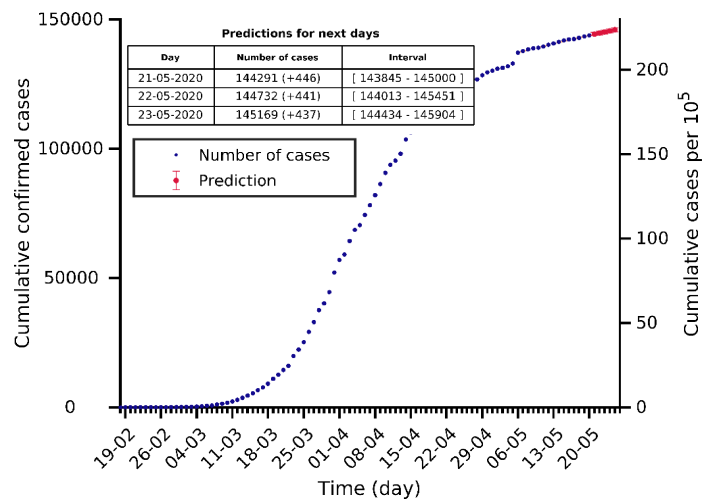
# Italy 20-05-2020. Population: 60.5M. Current cumulated incidence: 376/10<sup>5</sup>



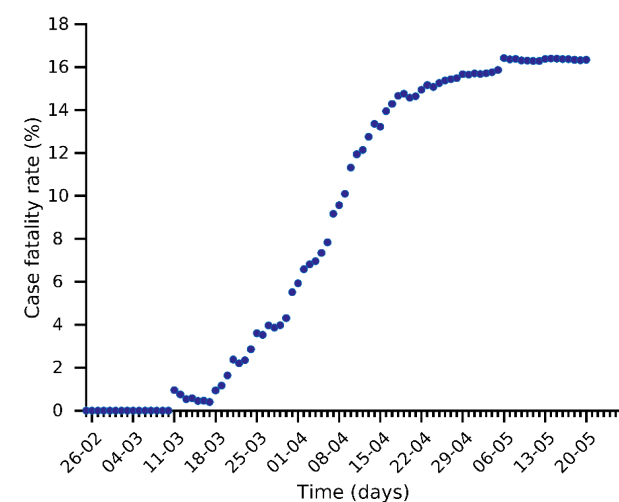
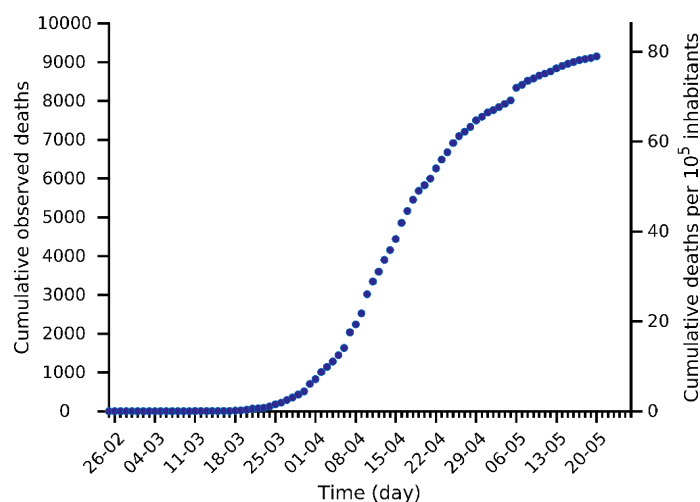
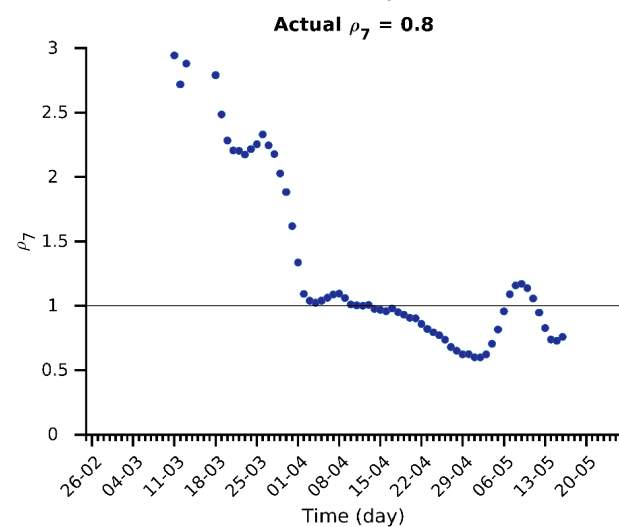
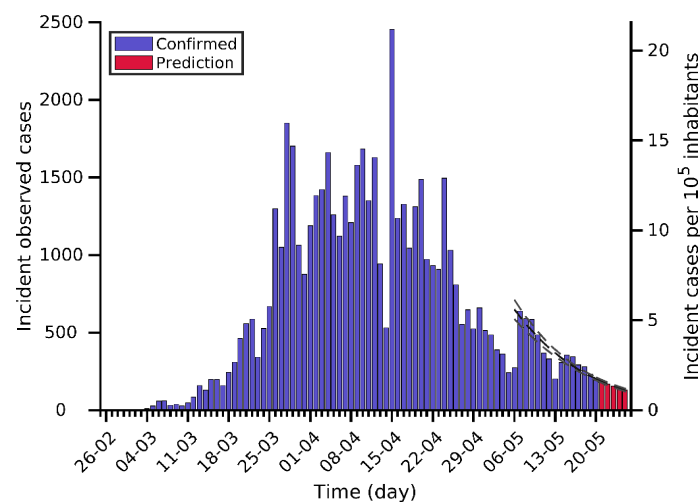
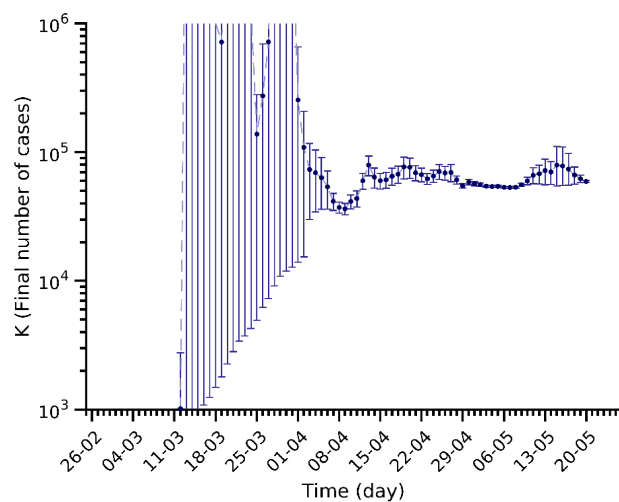
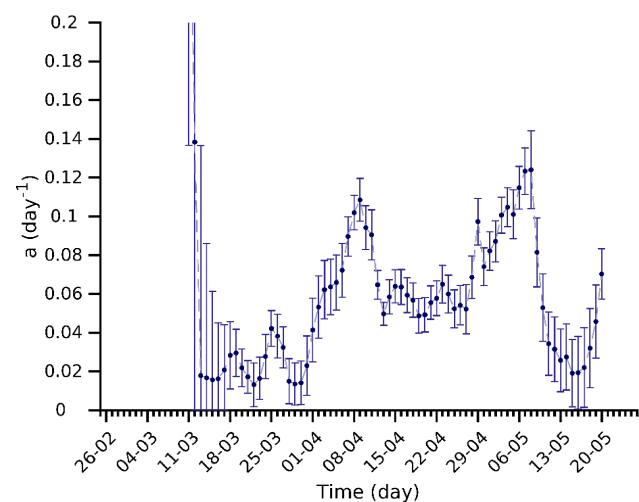
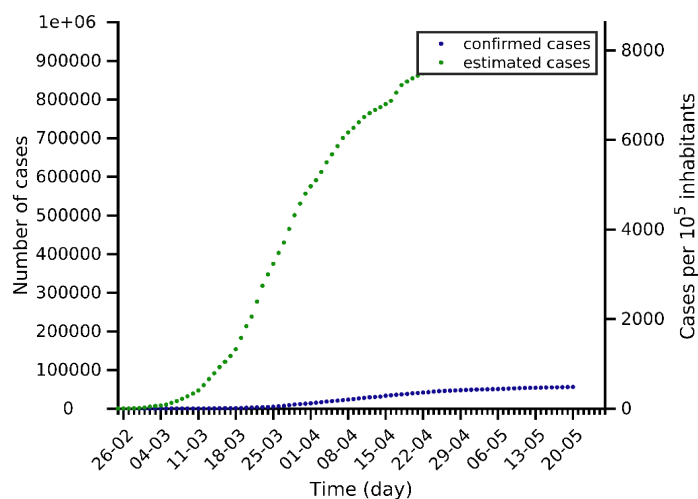
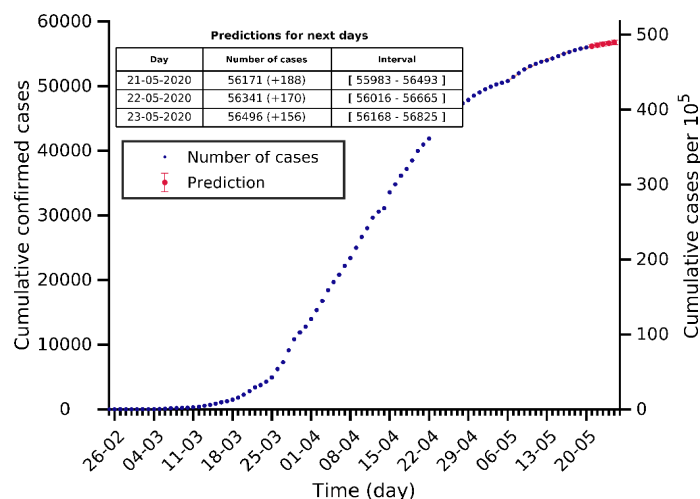
# Germany 20-05-2020. Population: 83.8M. Current cumulated incidence: 211/10<sup>5</sup>



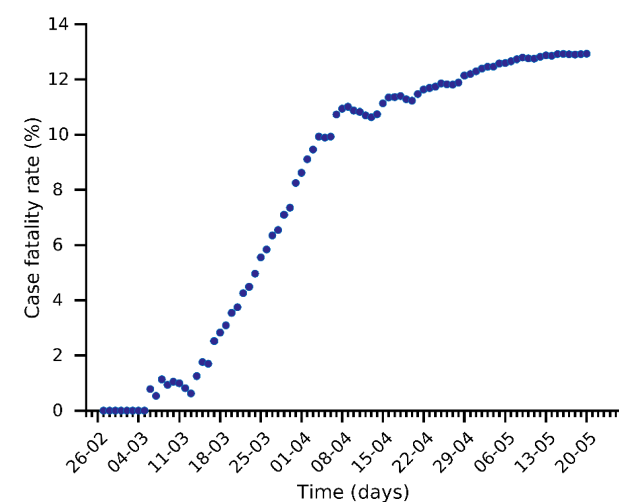
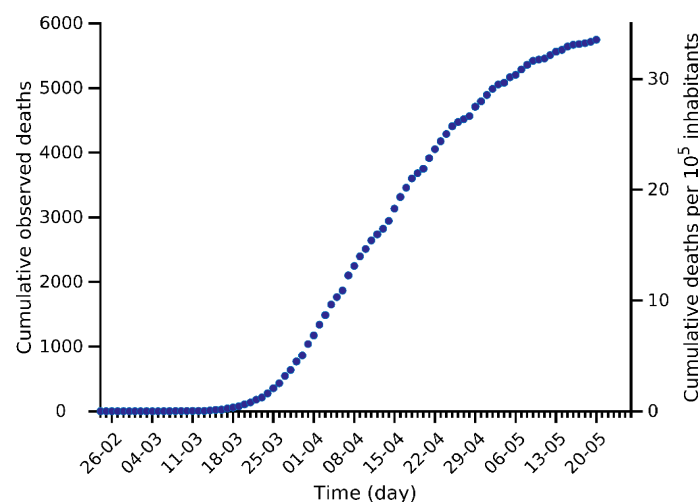
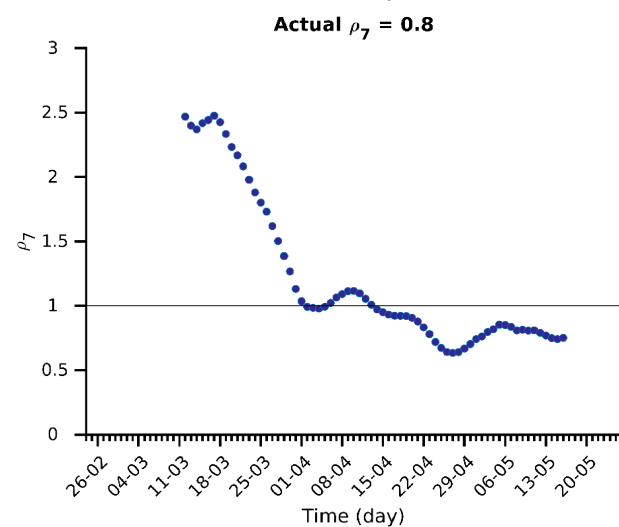
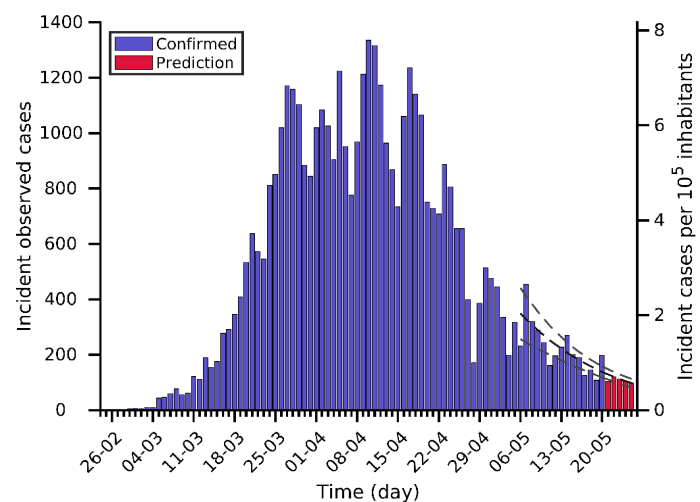
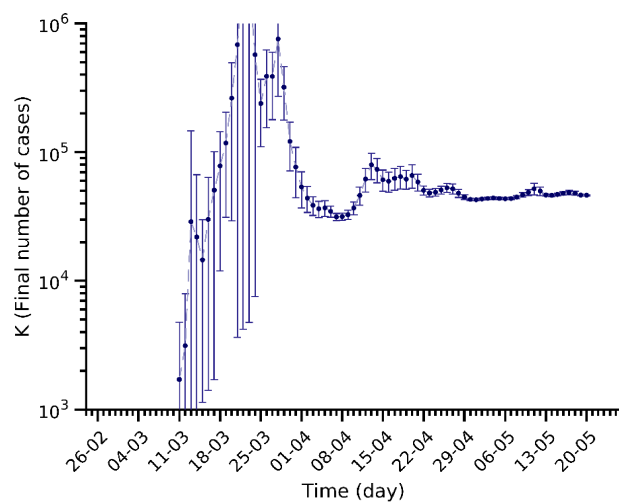
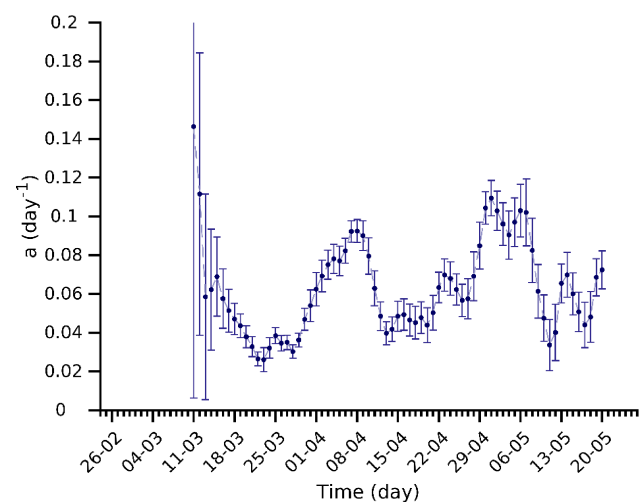
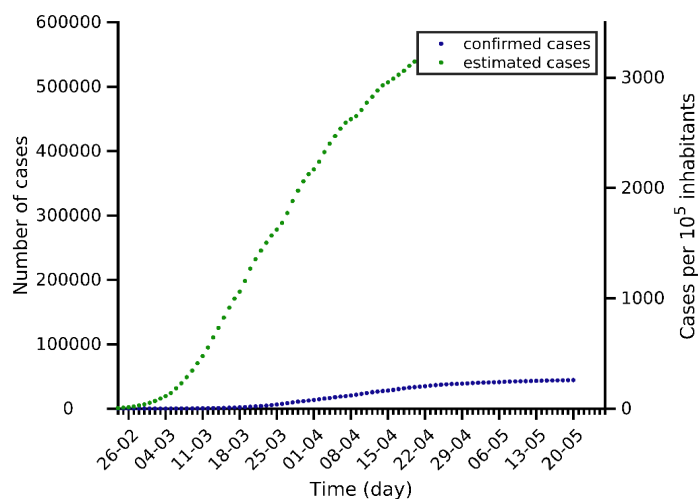
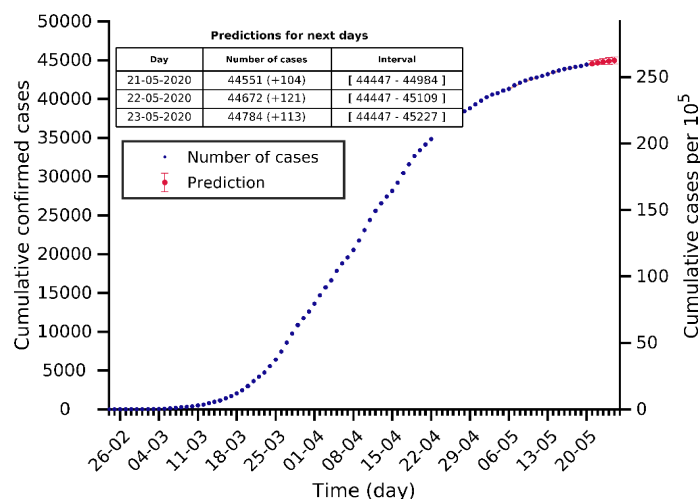
# France 20-05-2020. Population: 65.3M. Current cumulated incidence: 220/10<sup>5</sup>



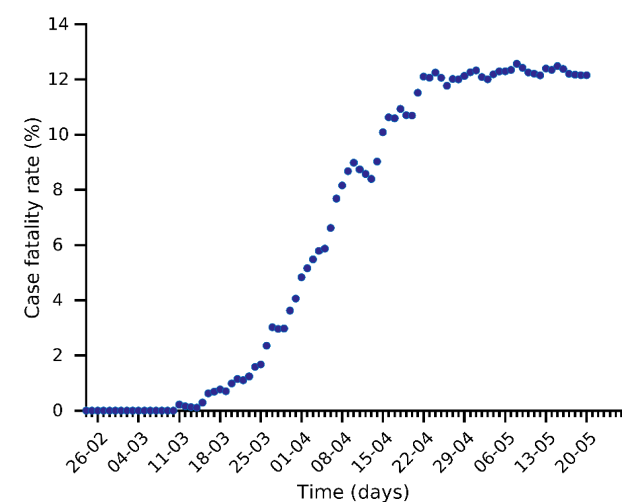
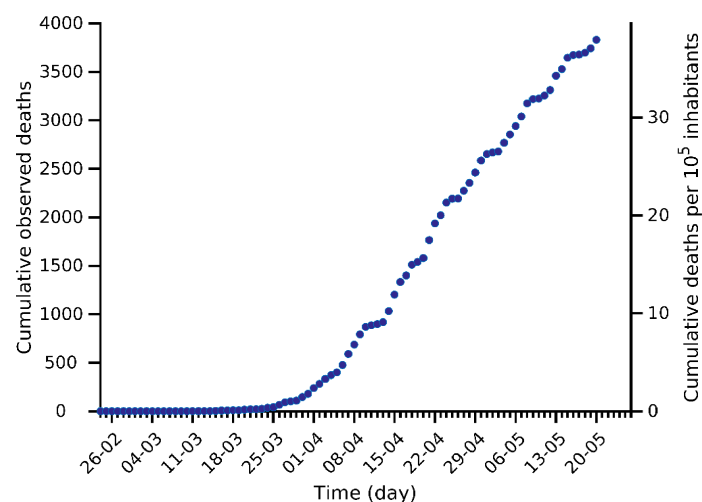
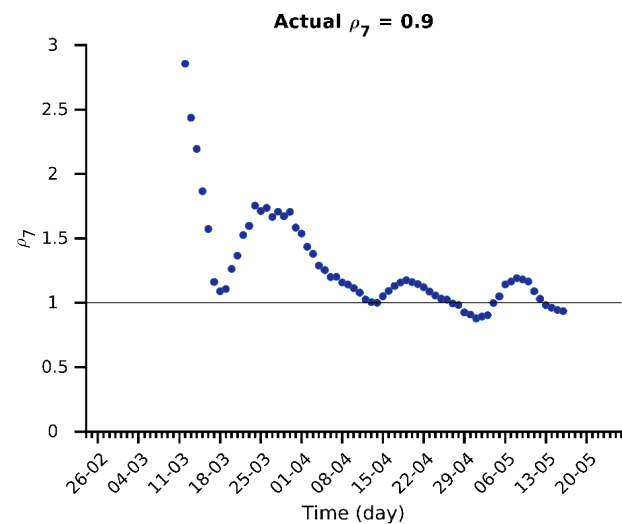
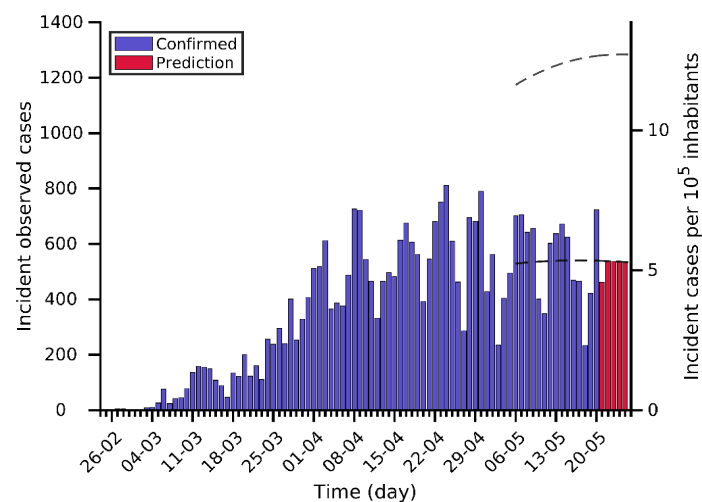
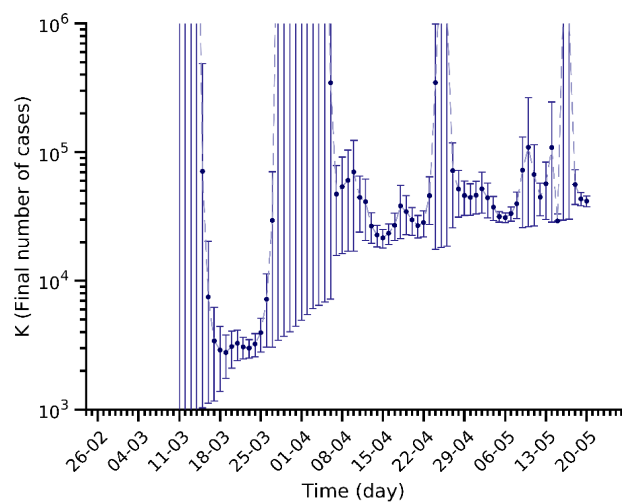
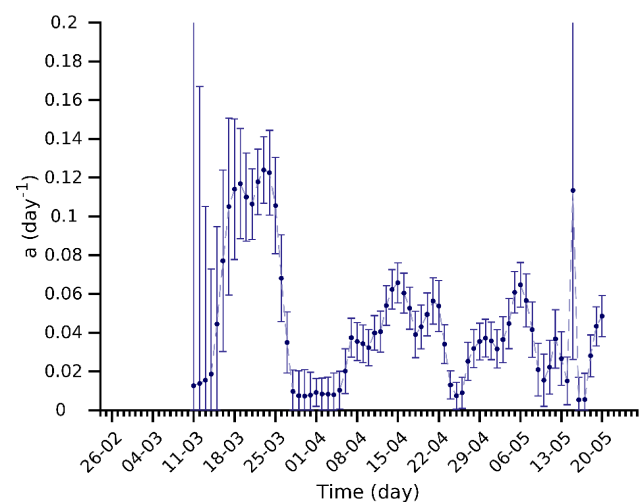
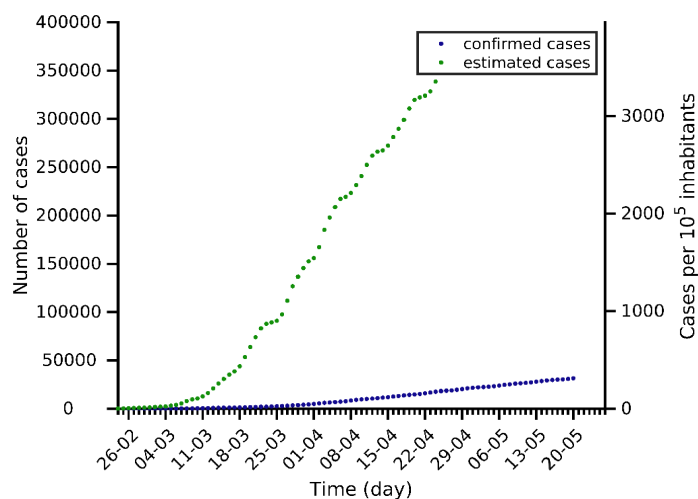
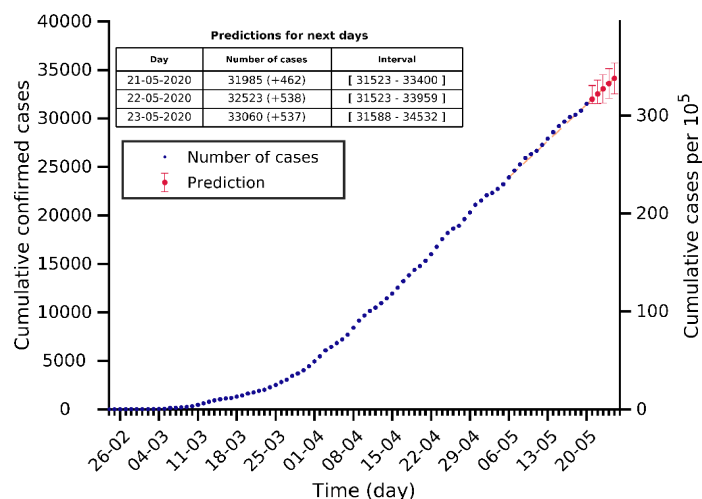
# Belgium 20-05-2020. Population: 11.6M. Current cumulated incidence: 483/10<sup>5</sup>



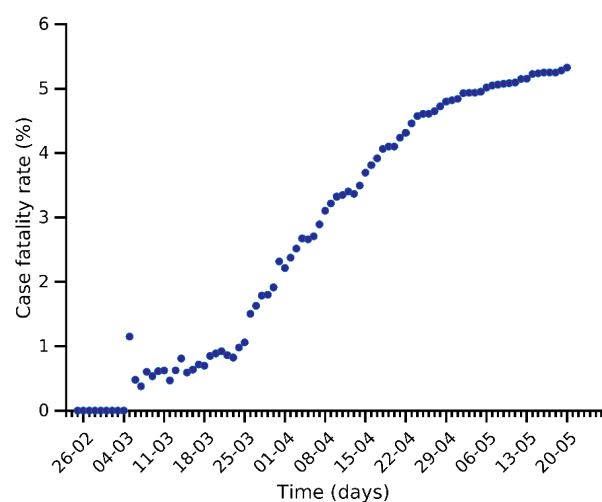
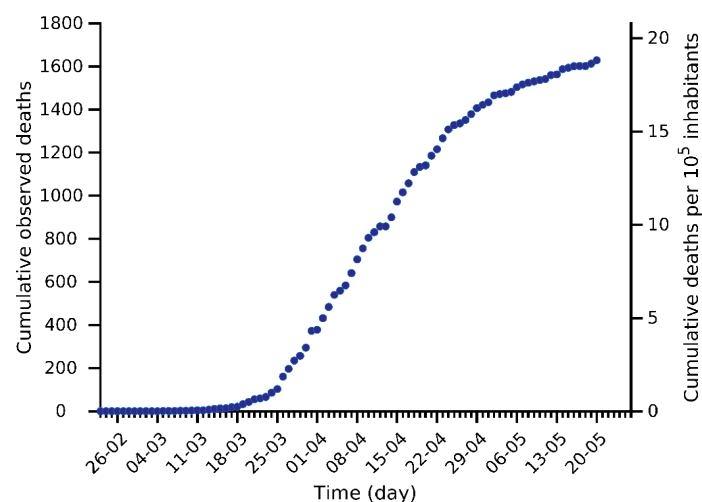
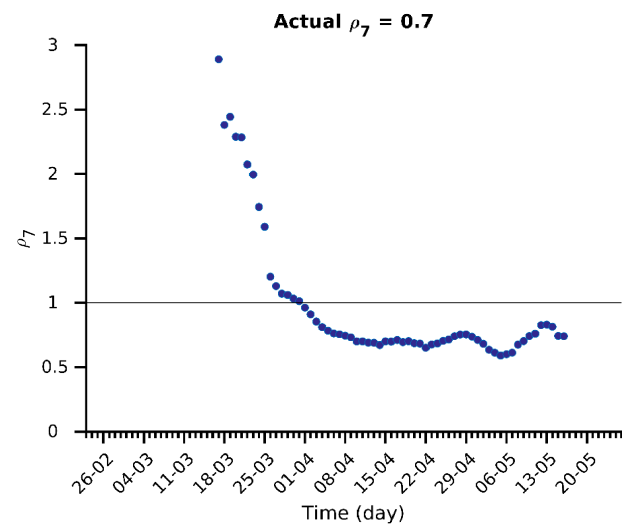
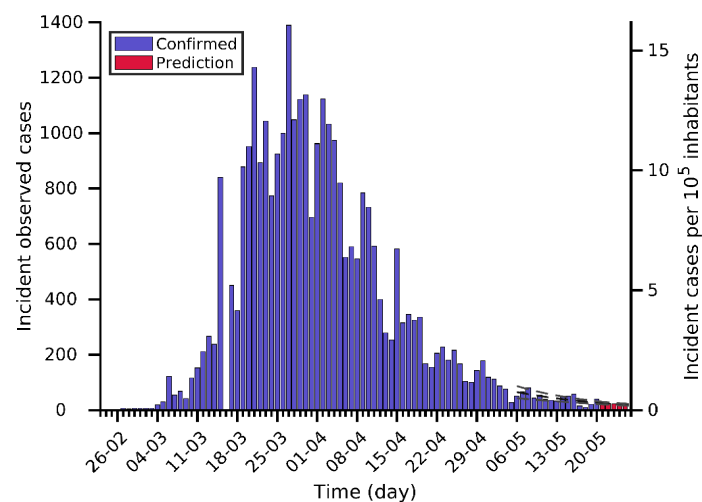
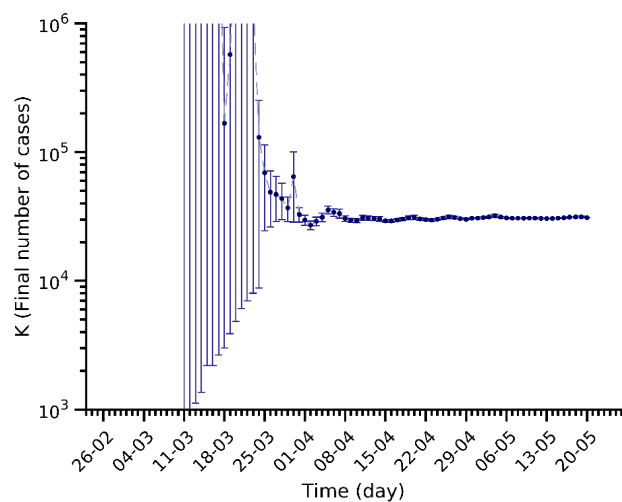
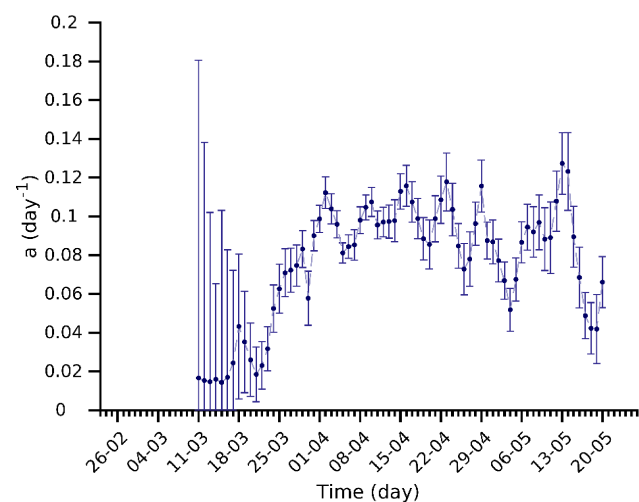
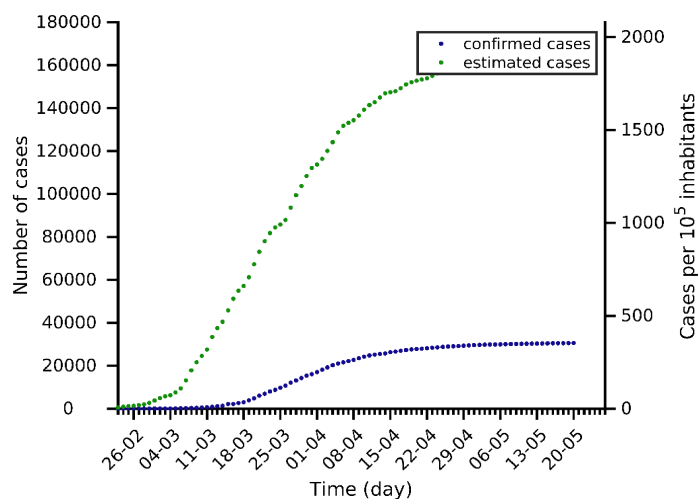
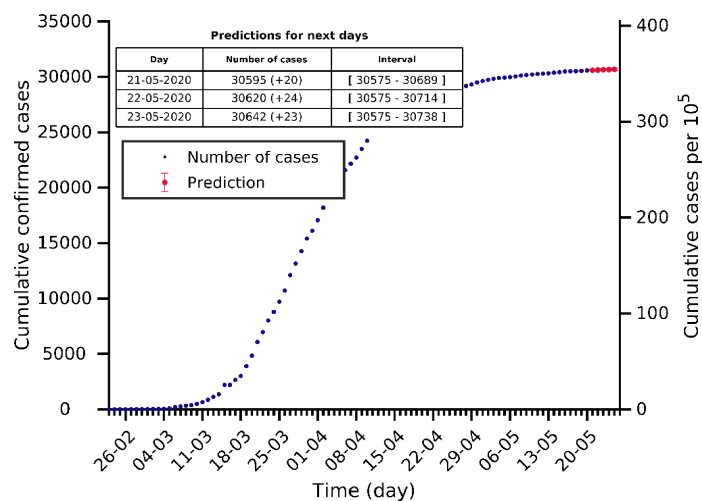
# Netherlands 20-05-2020. Population: 17.1M. Current cumulated incidence: 259/10<sup>5</sup>



# Sweden 20-05-2020. Population: 10.1M. Current cumulated incidence: 312/10<sup>5</sup>

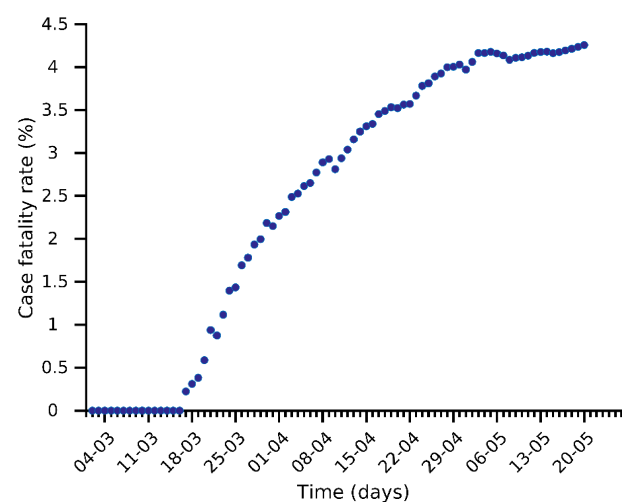
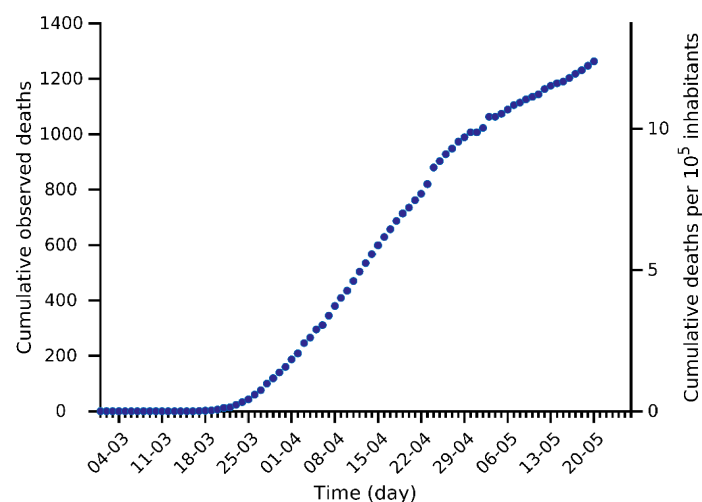
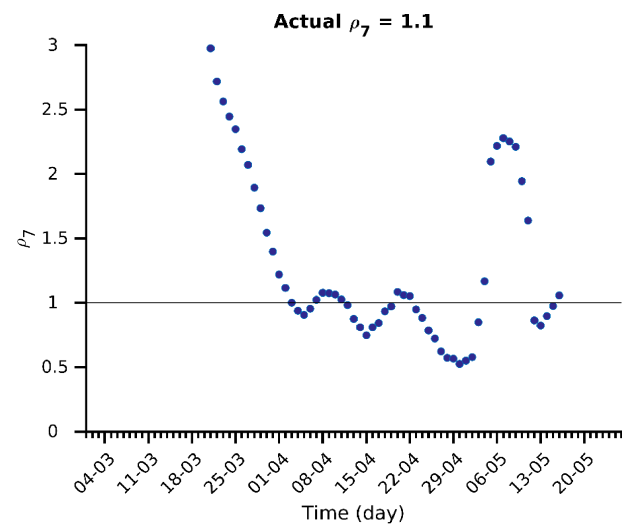
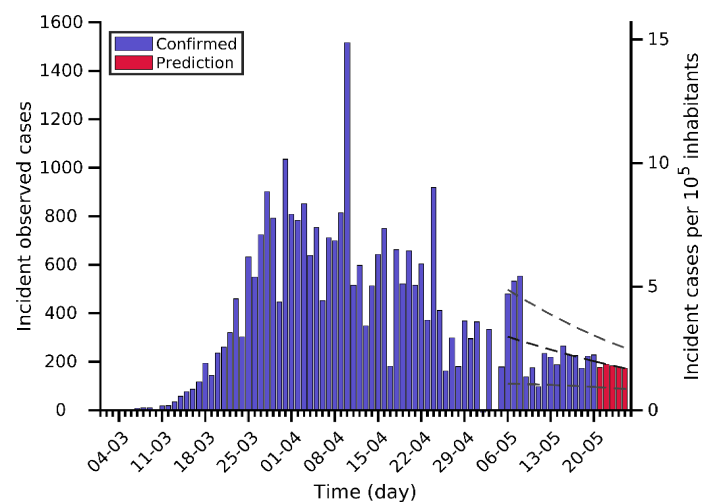
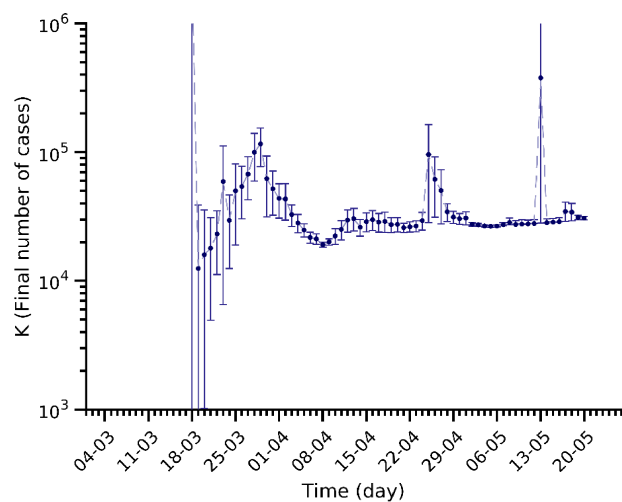
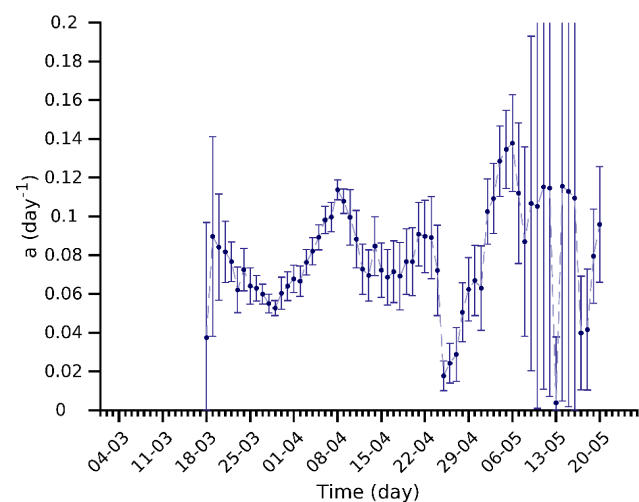
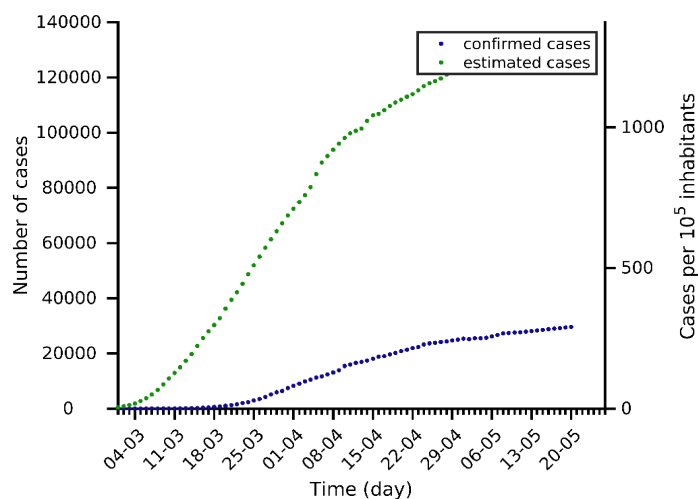
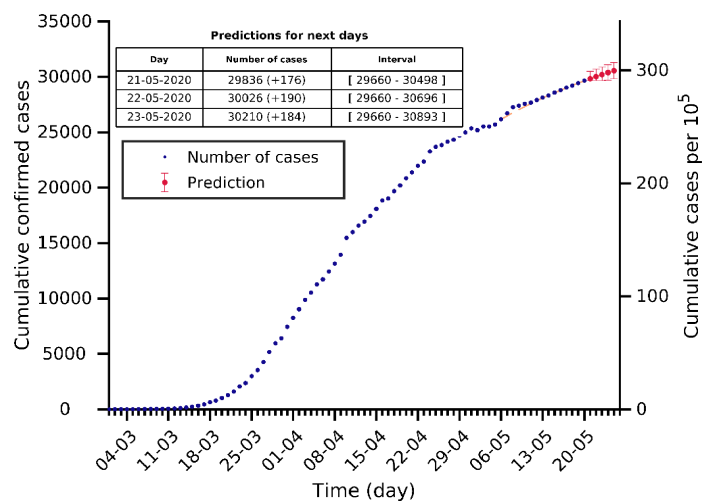


# Switzerland 20-05-2020. Population: 8.7M. Current cumulated incidence: 353/10<sup>5</sup>

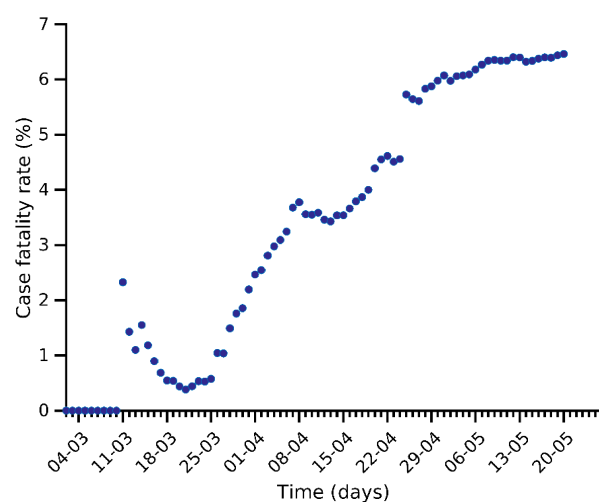
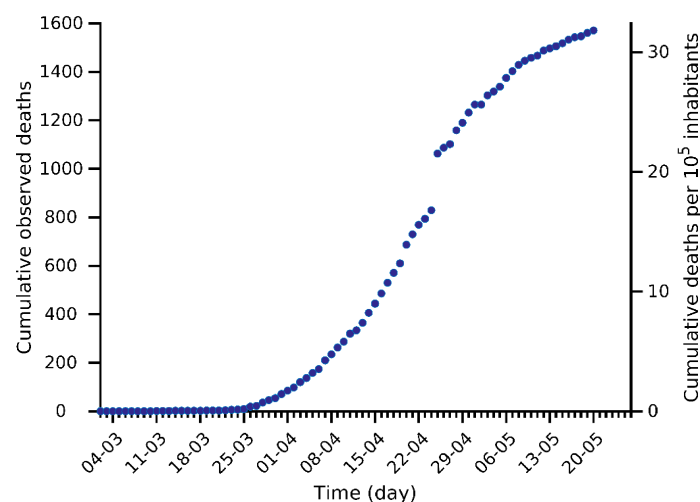
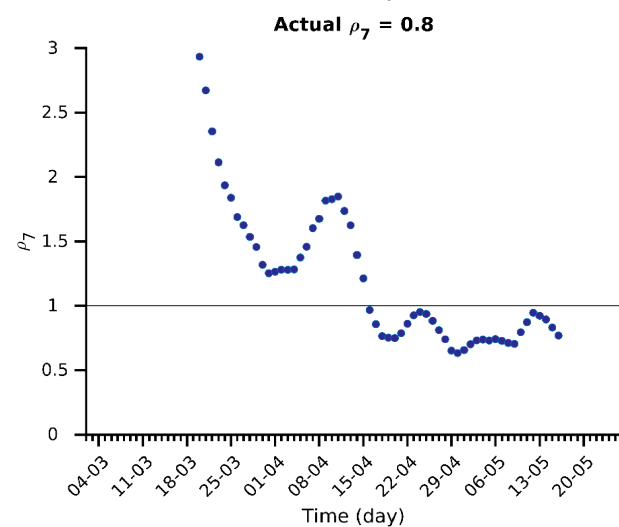
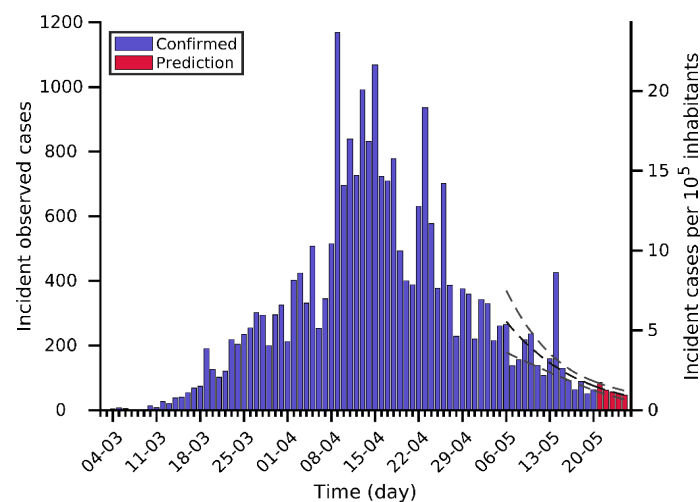
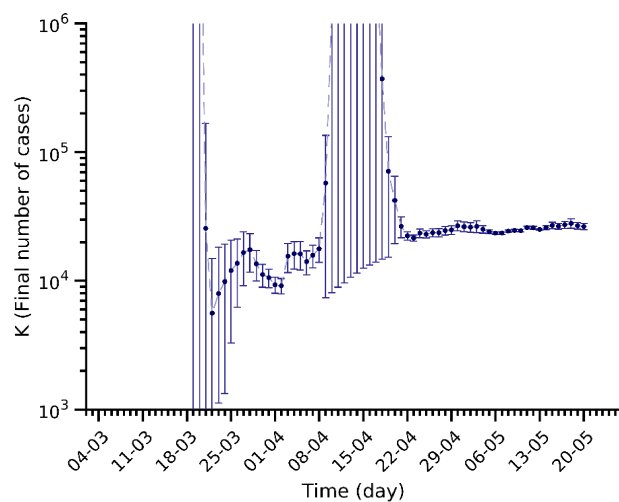
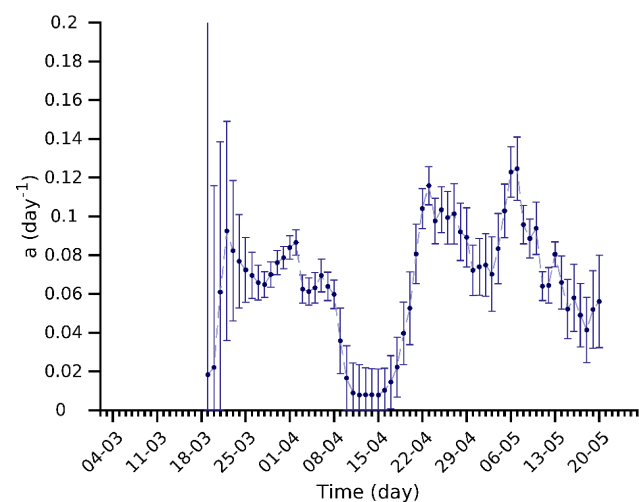
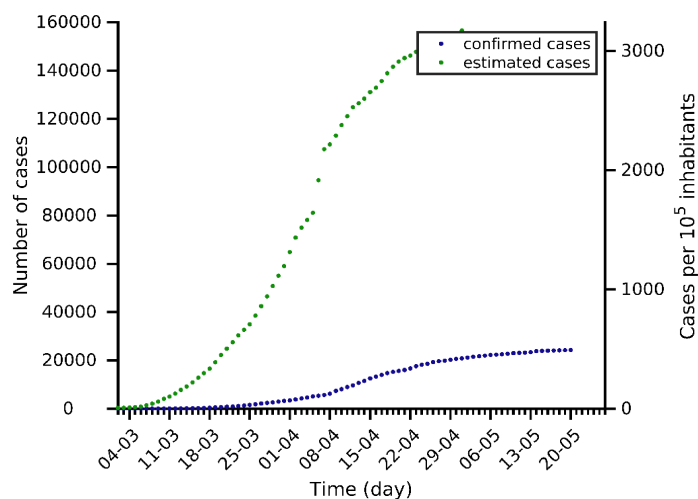
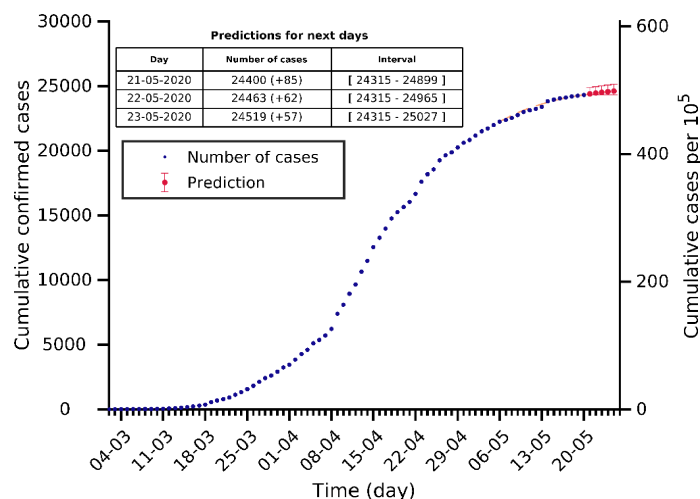




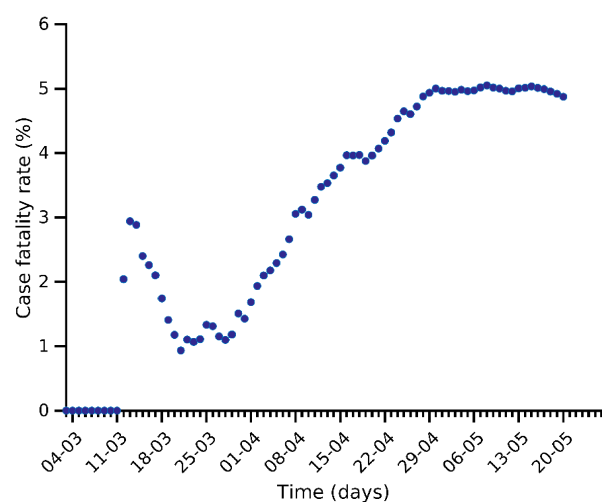
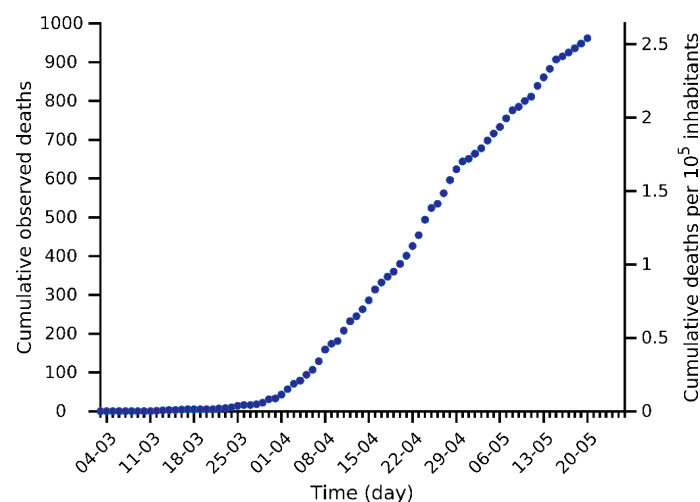
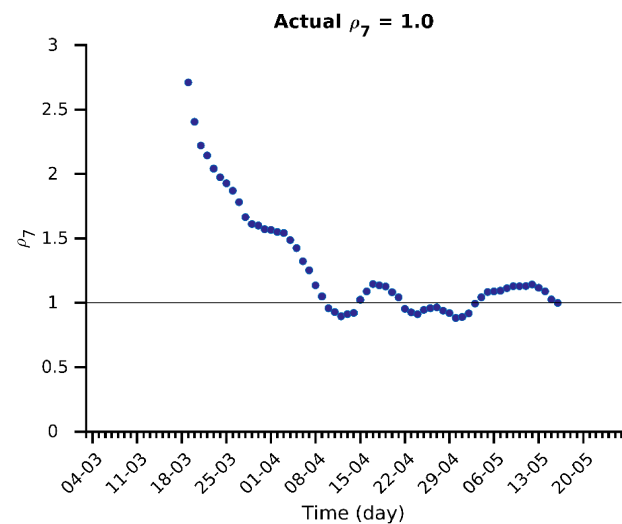
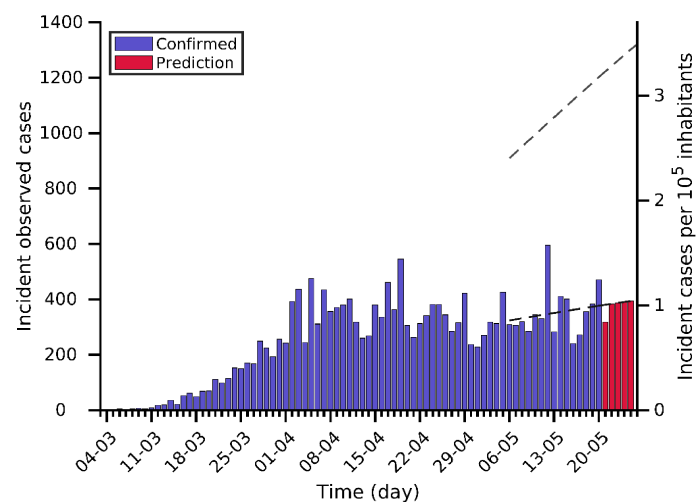
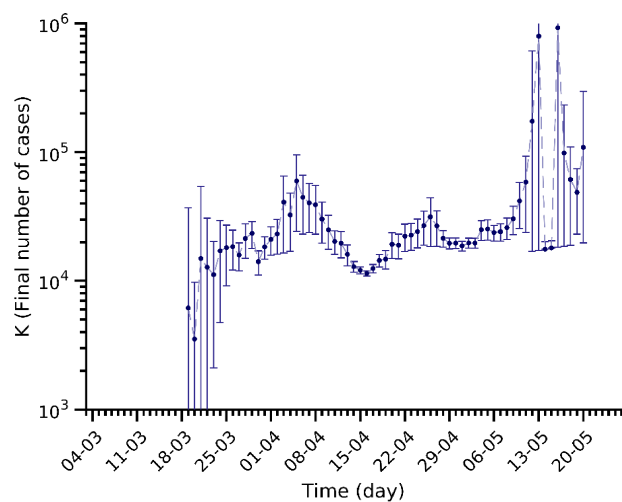
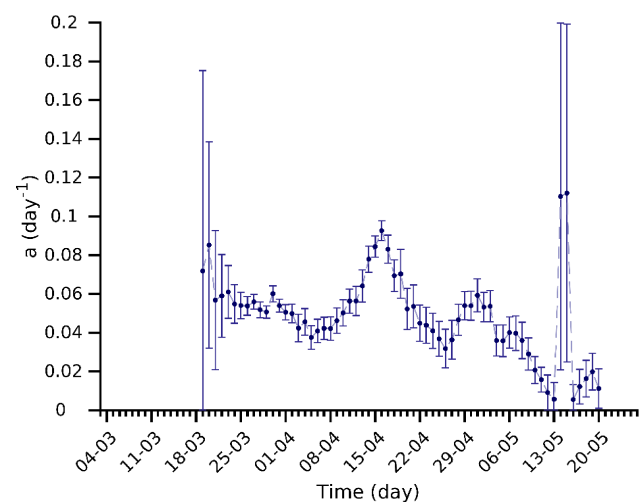
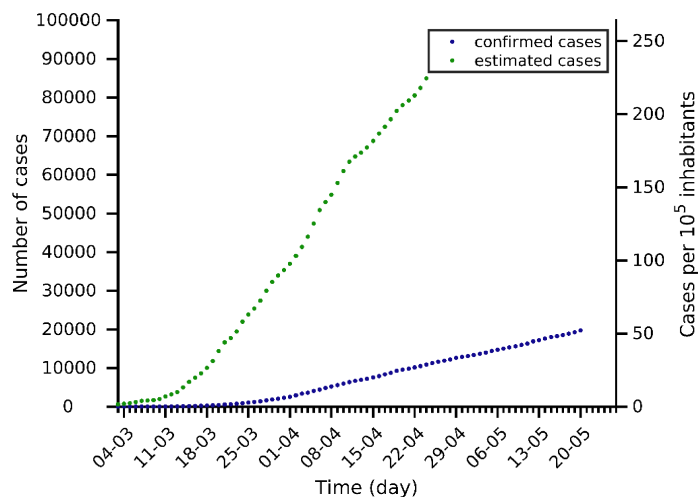
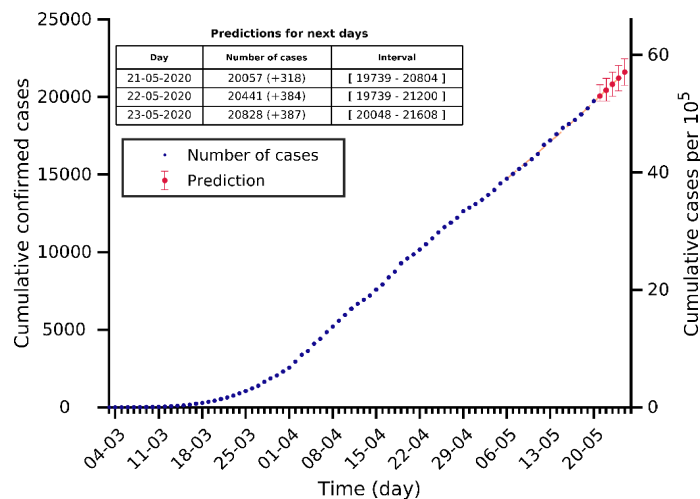
# Portugal 20-05-2020. Population: 10.2M. Current cumulated incidence: 291/10<sup>5</sup>



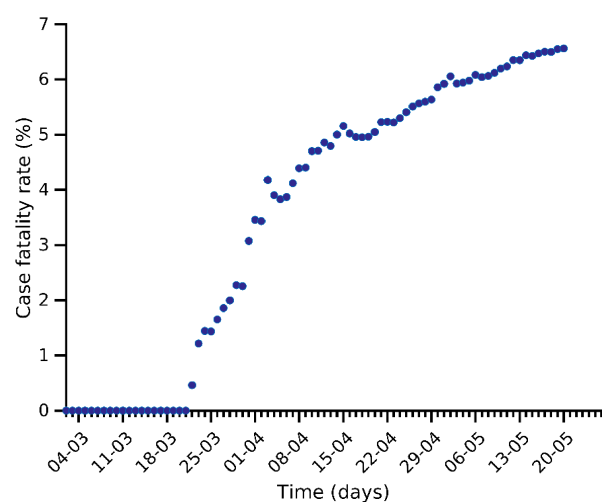
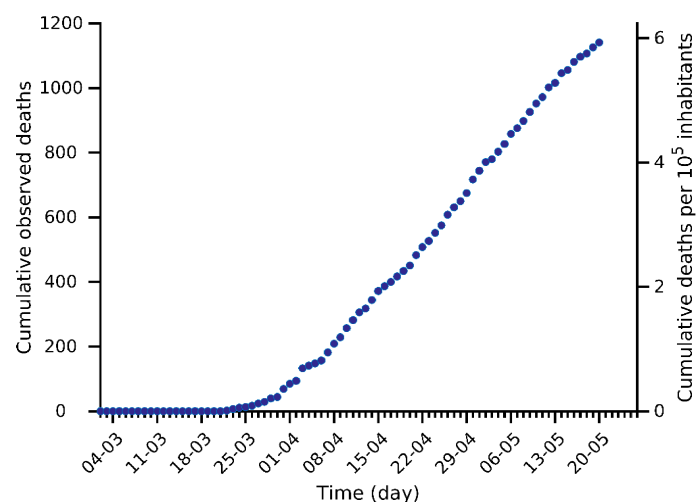
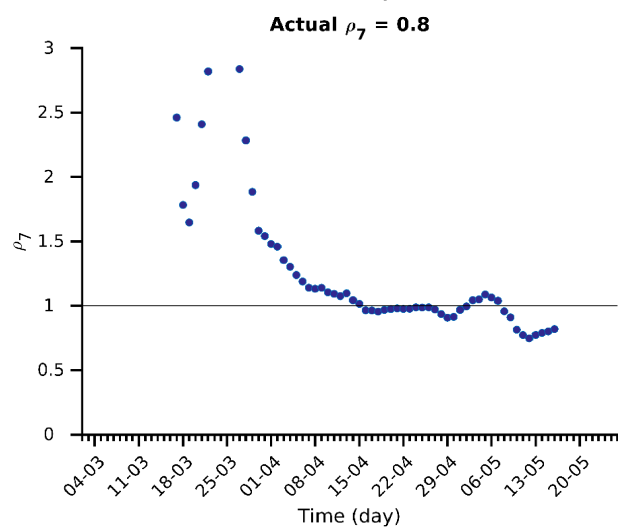
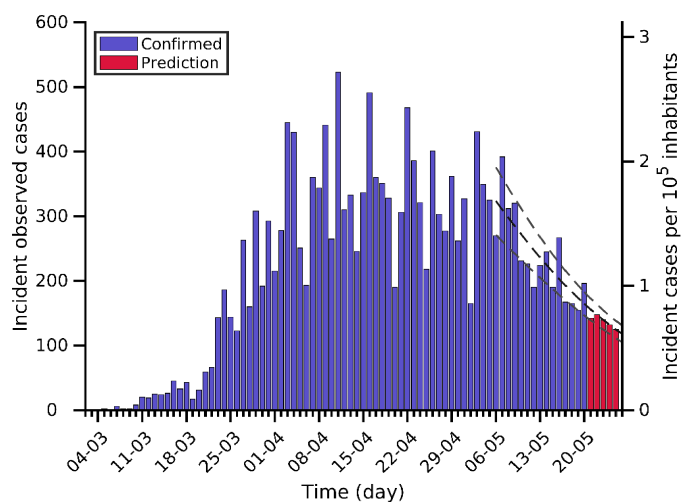
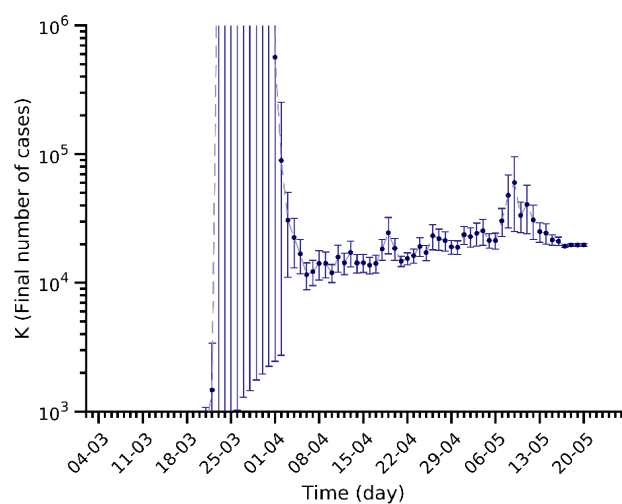
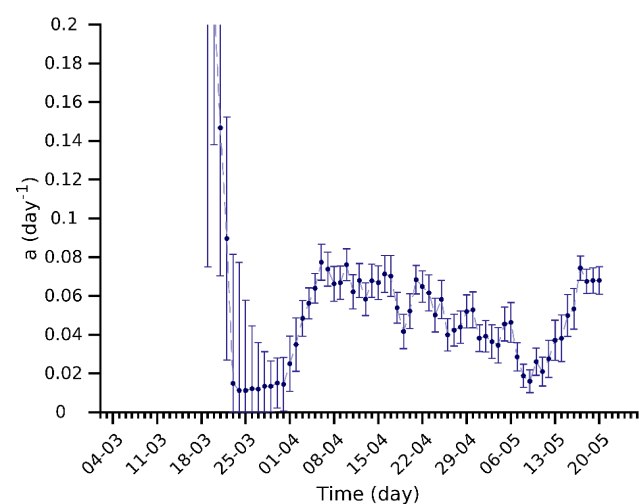
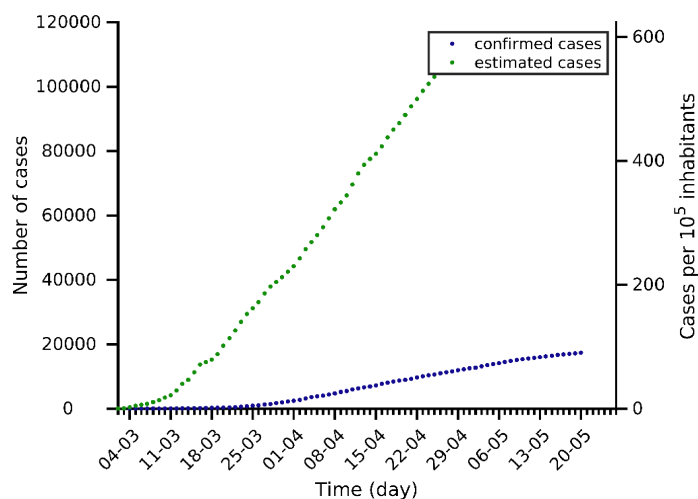
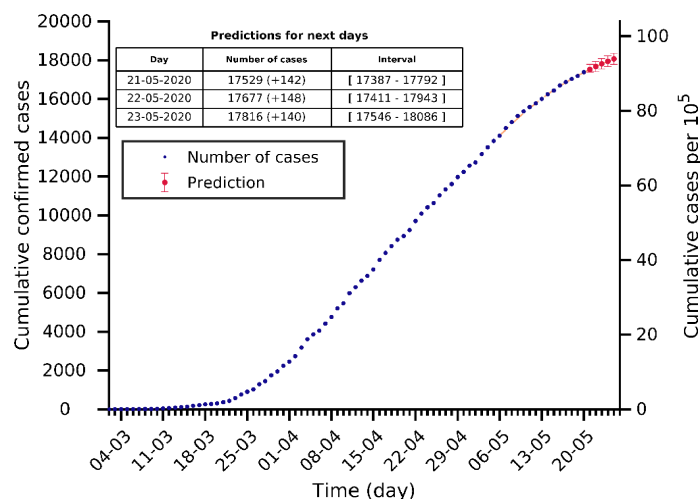
# Ireland 20-05-2020. Population: 4.9M. Current cumulated incidence: 492/10<sup>5</sup>



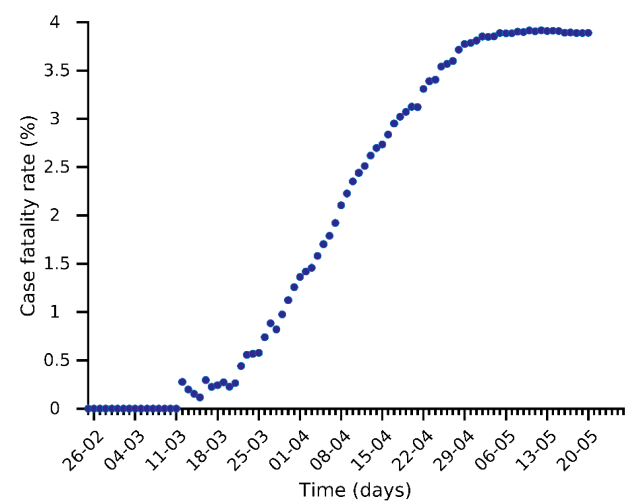
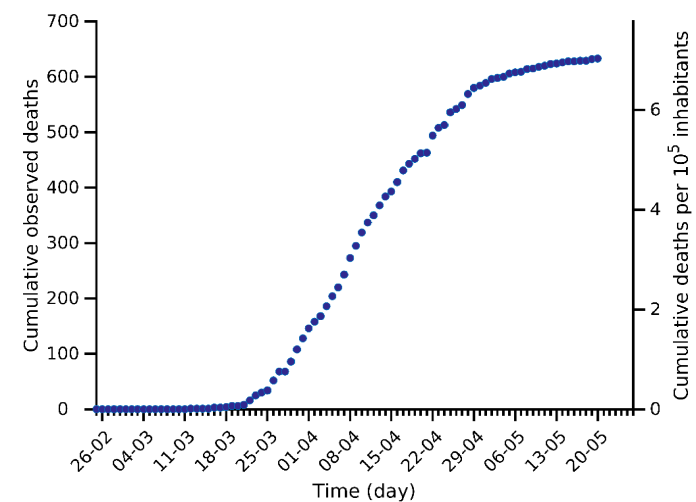
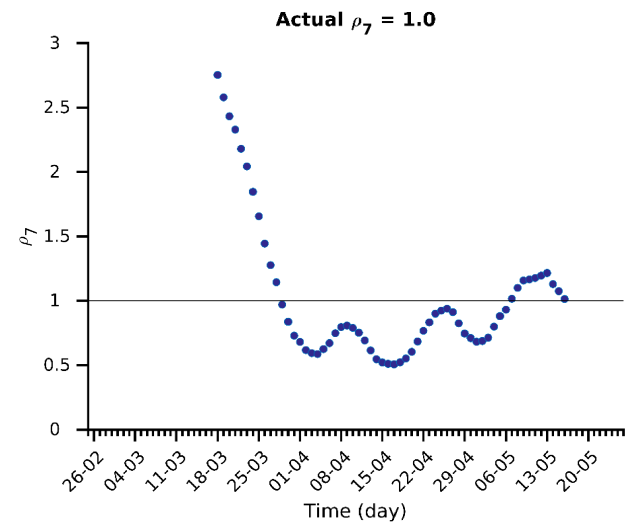
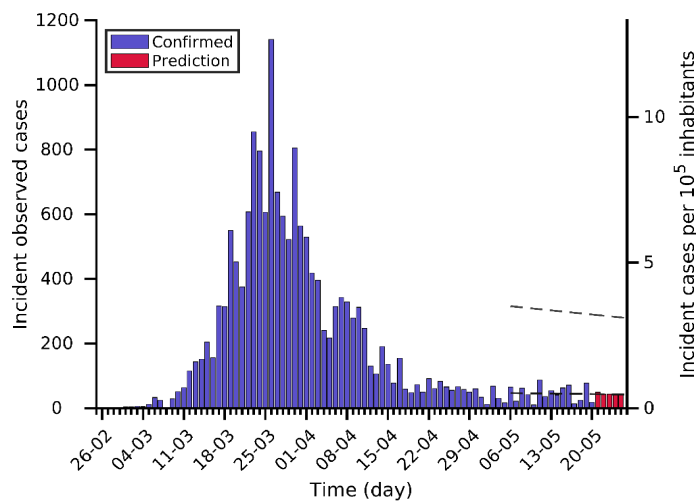
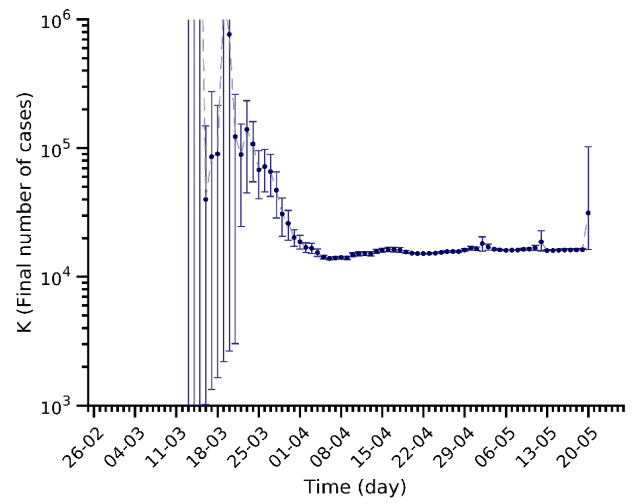
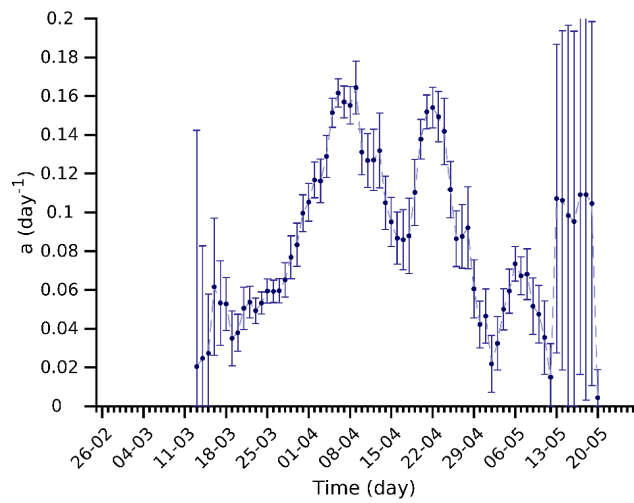
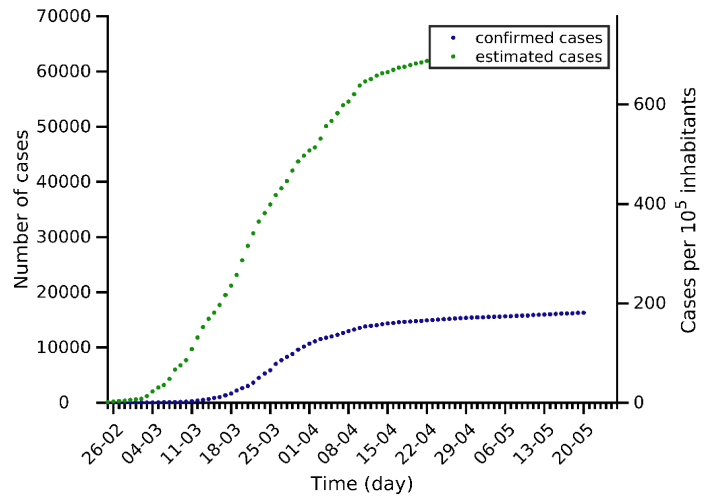
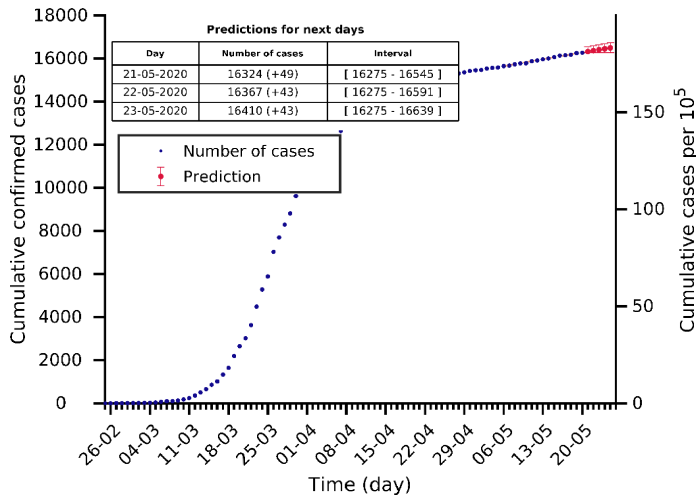
# Poland 20-05-2020. Population: 37.8M. Current cumulated incidence: 52/10<sup>5</sup>



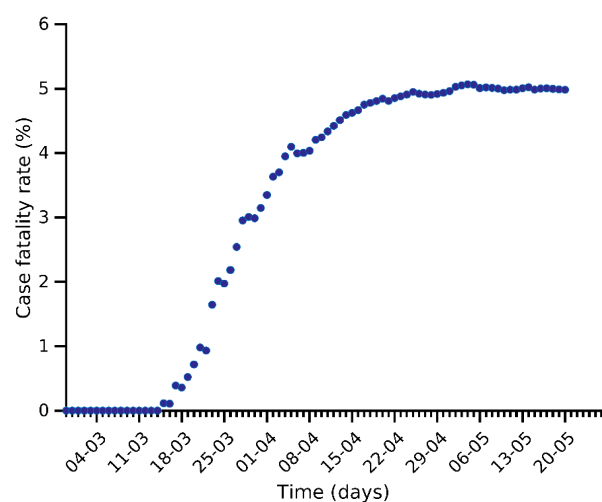
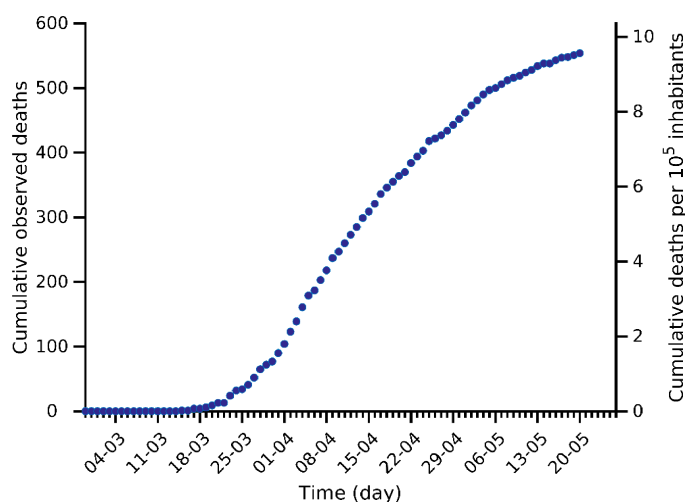
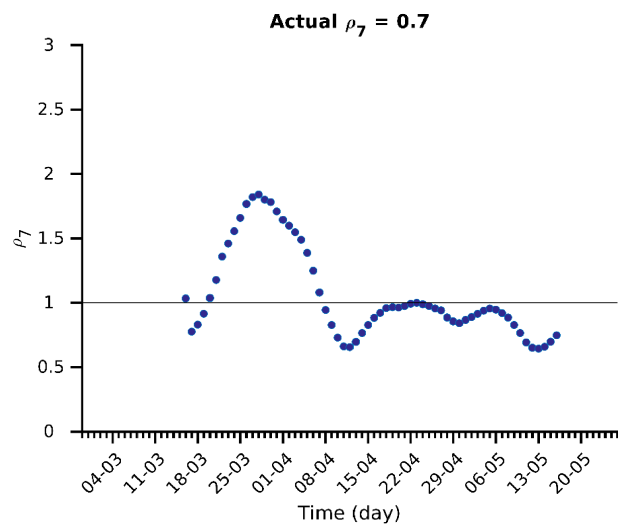
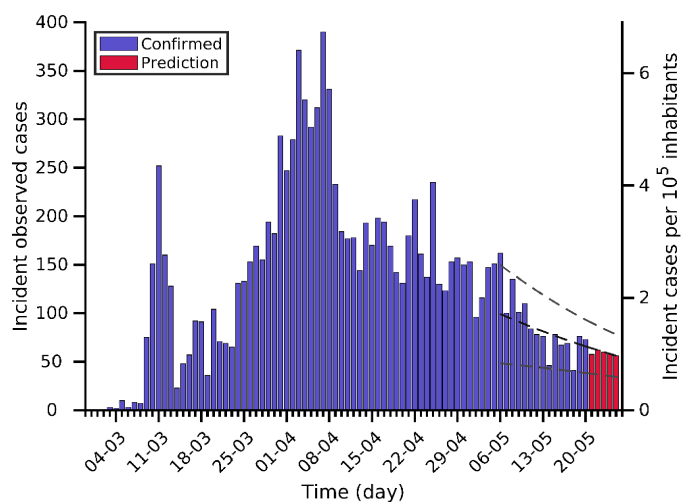
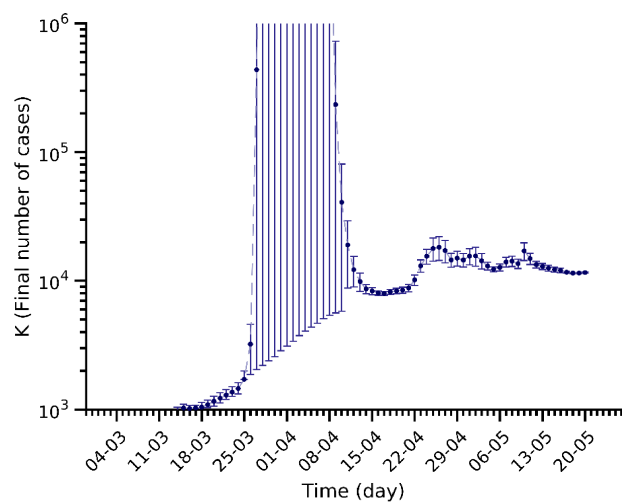
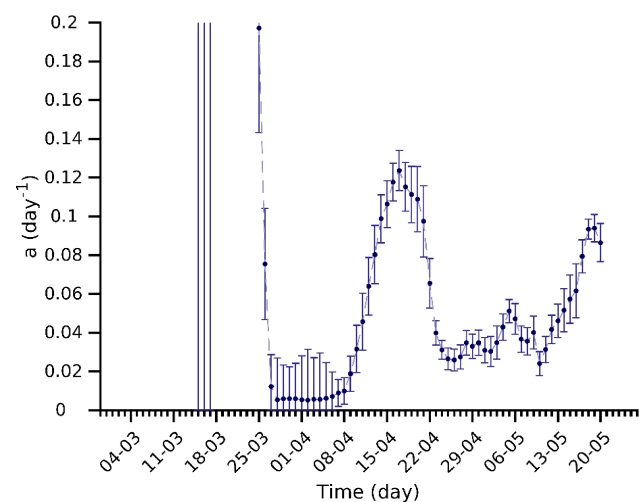
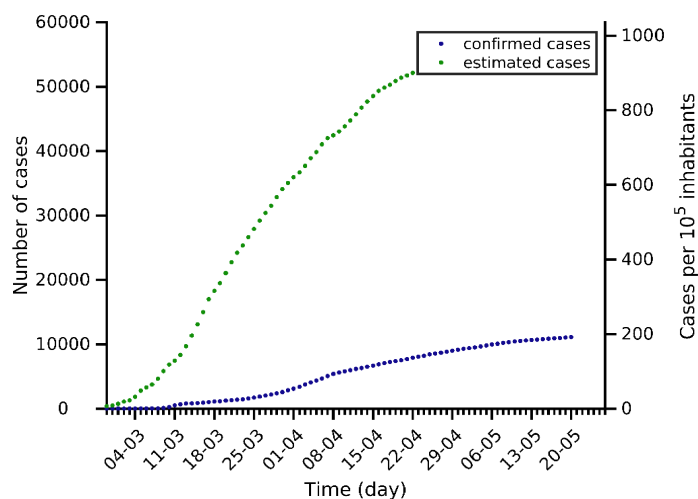
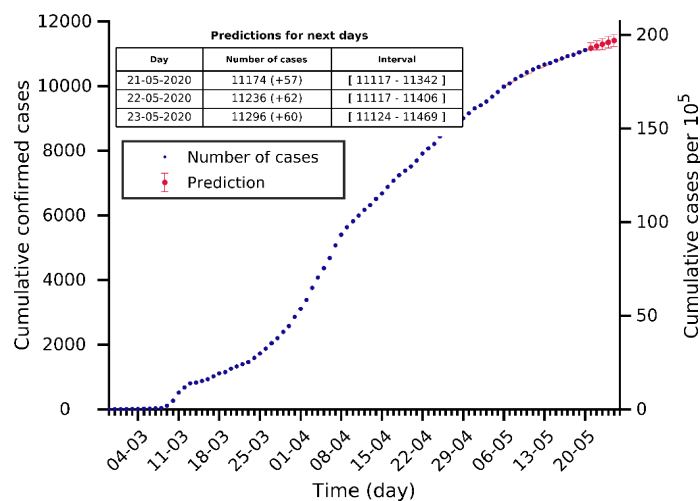
# Romania 20-05-2020. Population: 19.2M. Current cumulated incidence: 90/10<sup>5</sup>



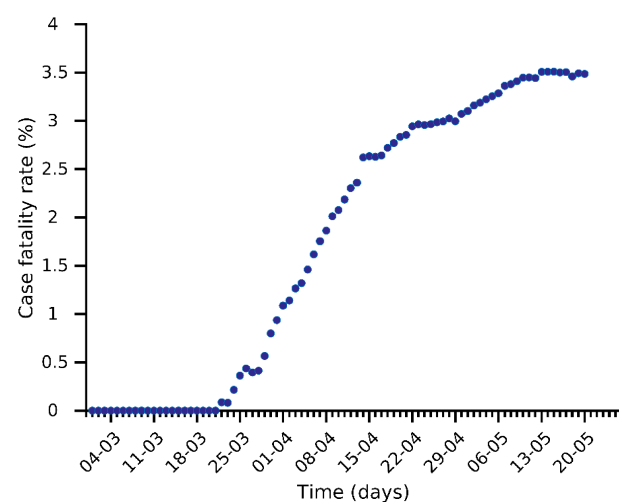
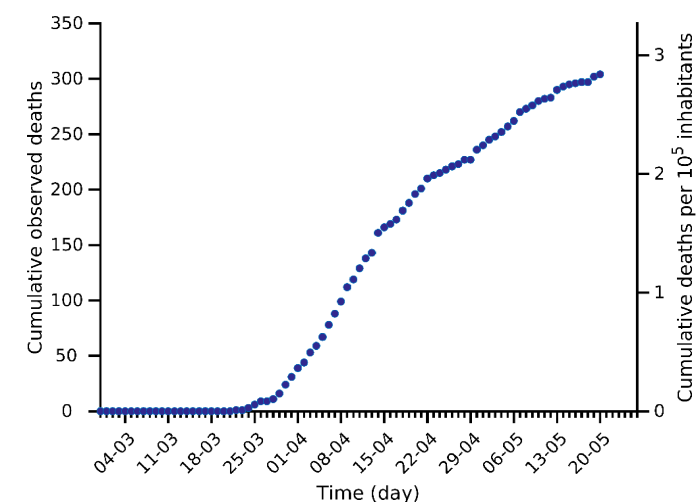
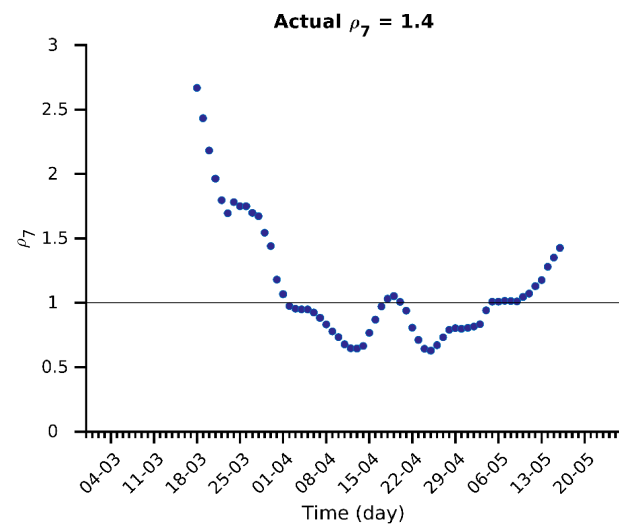
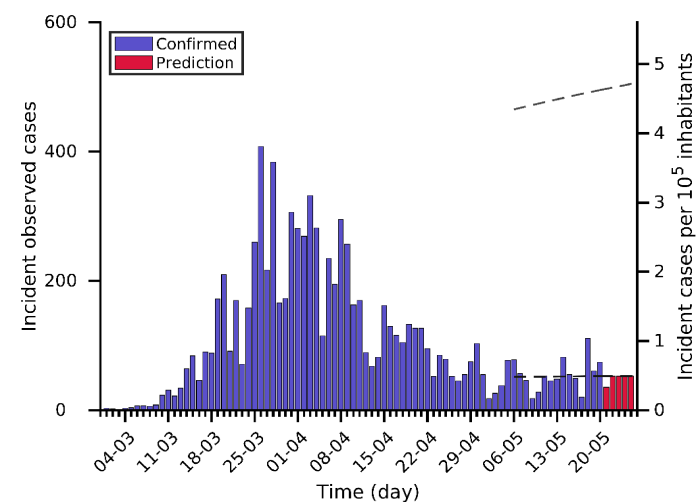
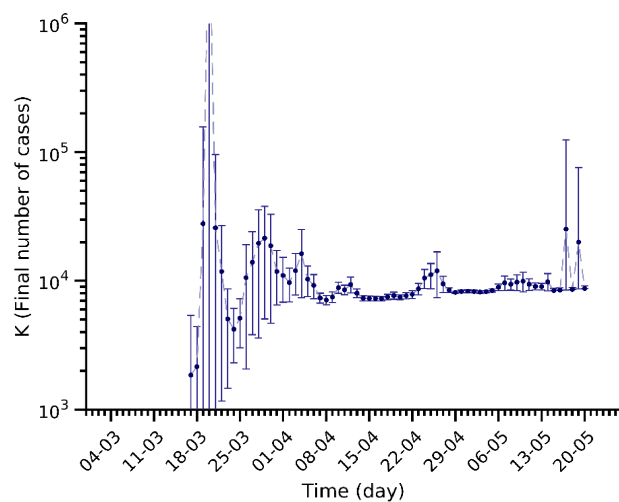
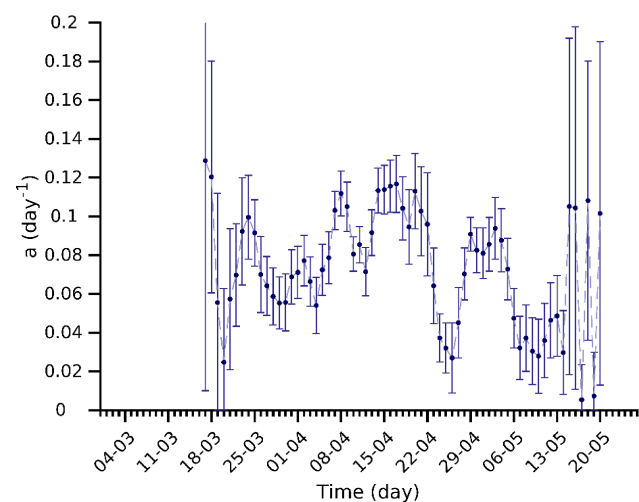
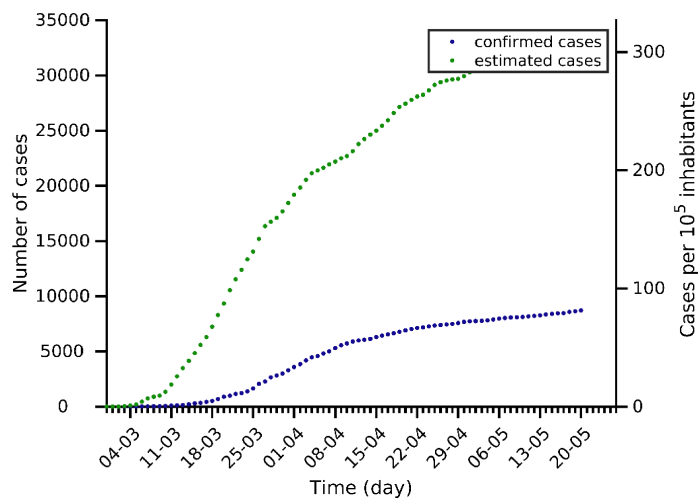
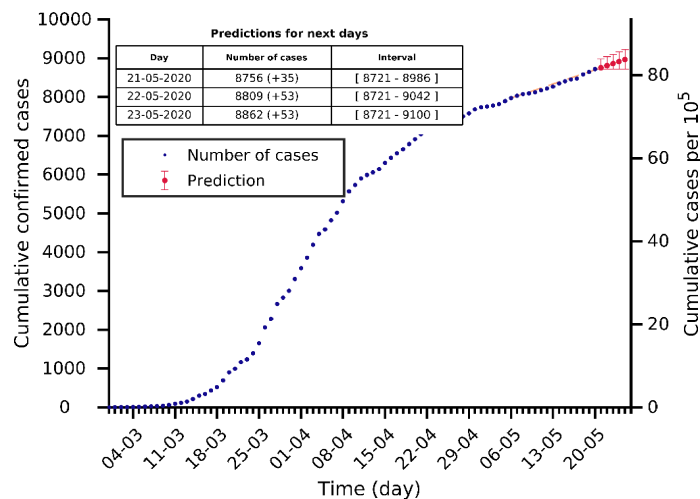
# Austria 20-05-2020. Population: 9.0M. Current cumulated incidence: 181/10<sup>5</sup>



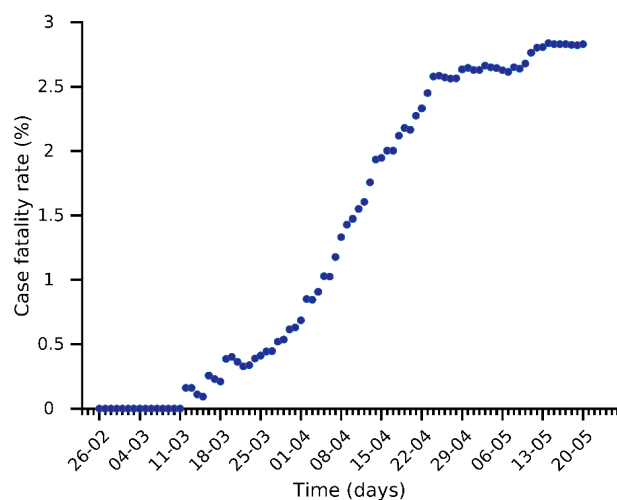
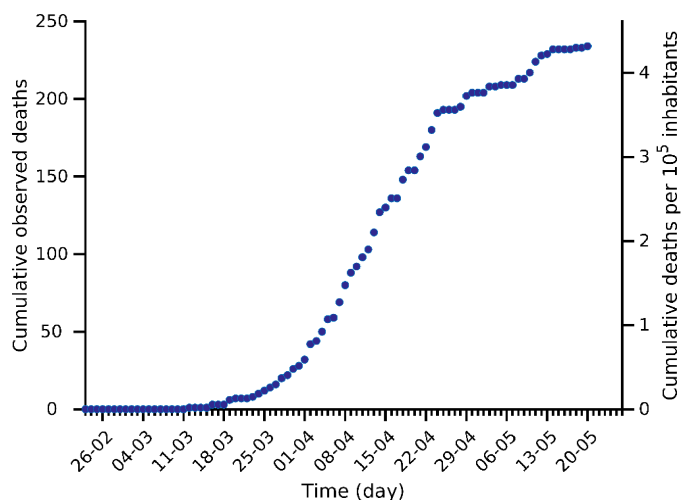
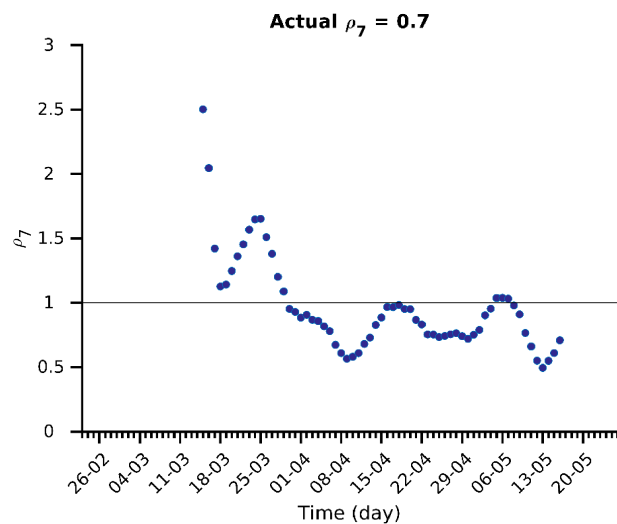
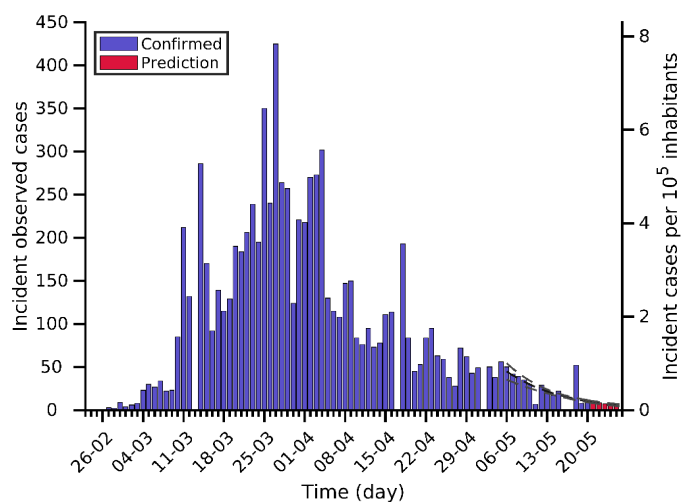
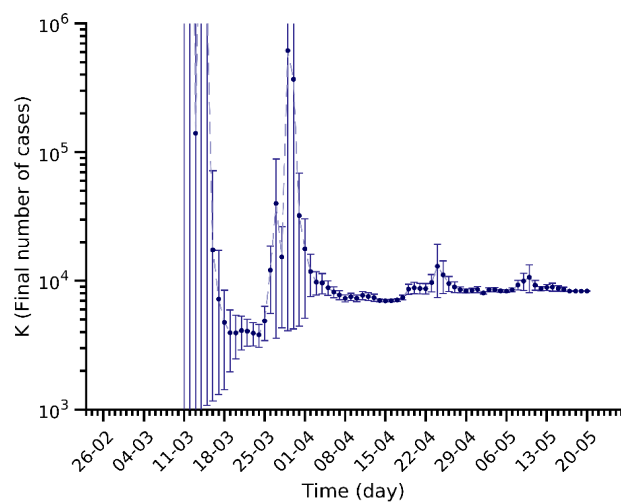
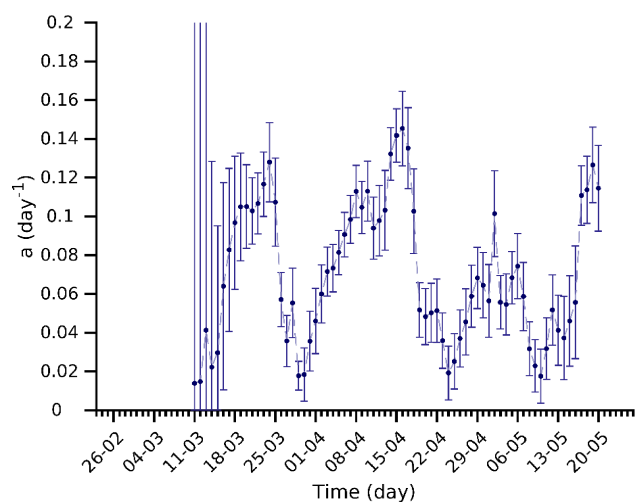
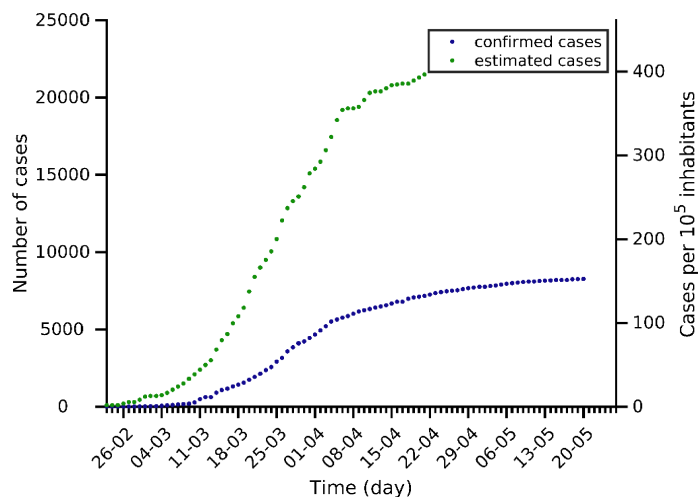
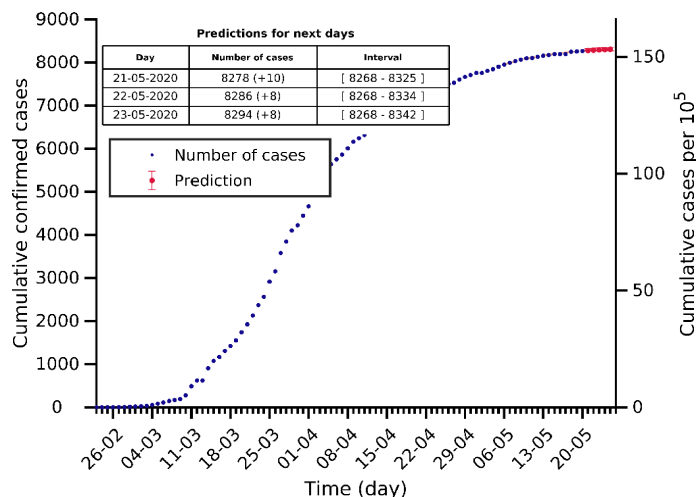
# Denmark 20-05-2020. Population: 5.8M. Current cumulated incidence: 192/10<sup>5</sup>



# Czech Rep 20-05-2020. Population: 10.7M. Current cumulated incidence: 81/10<sup>5</sup>

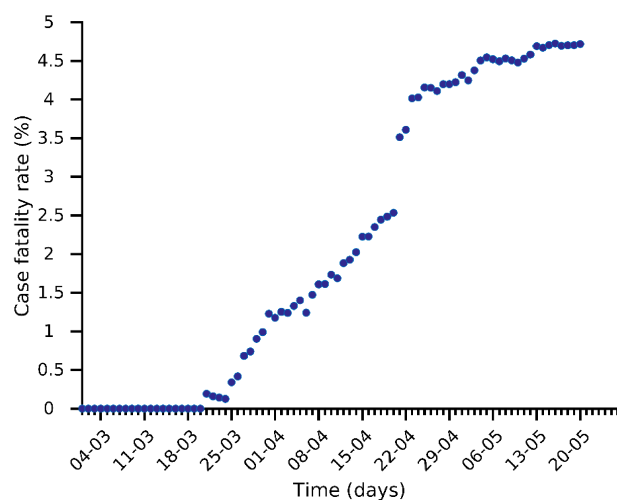
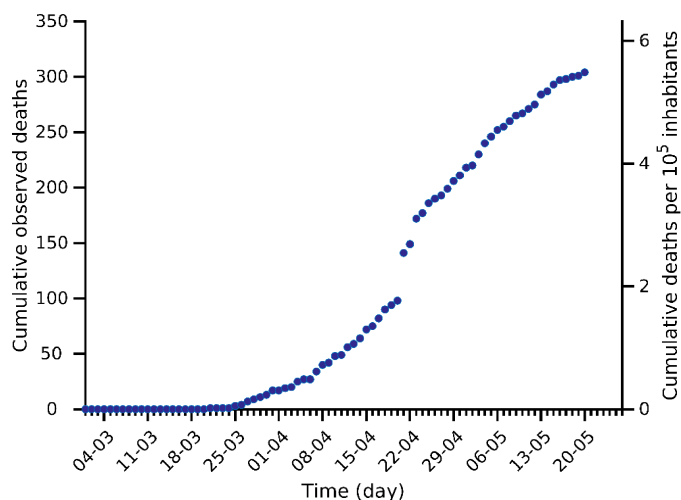
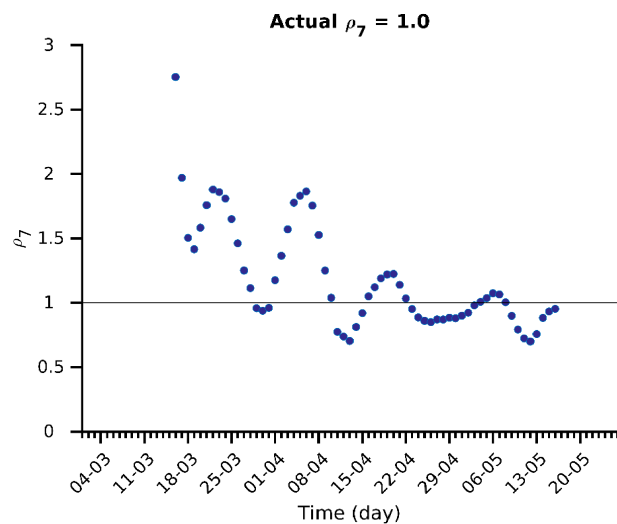
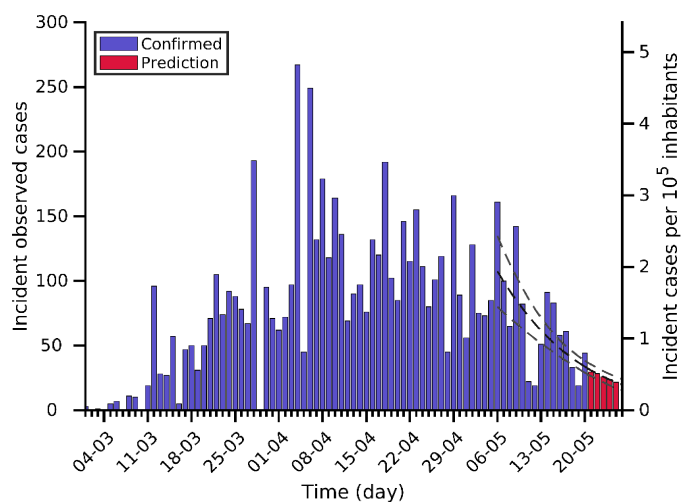
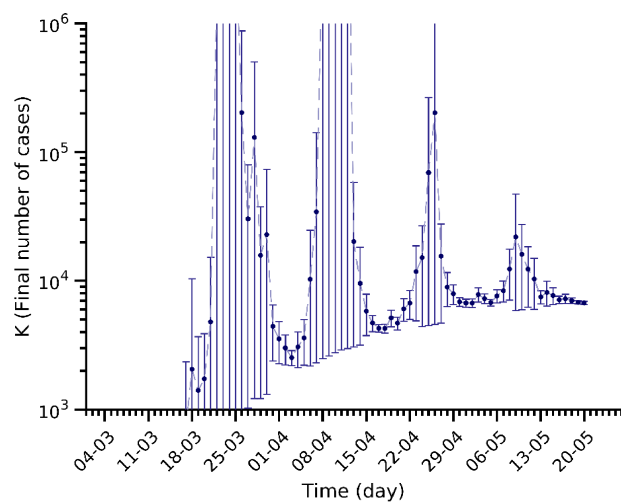
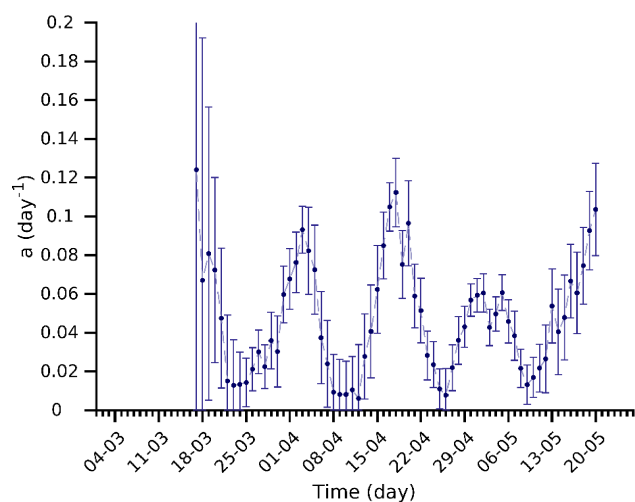
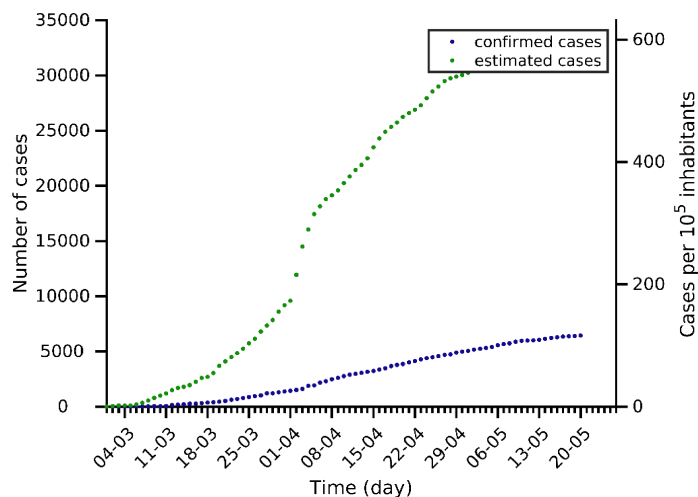
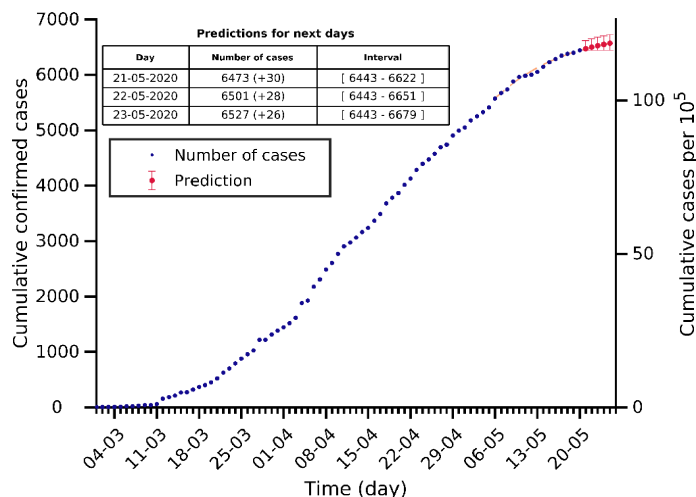


# Norway 20-05-2020. Population: 5.4M. Current cumulated incidence: 153/10<sup>5</sup>

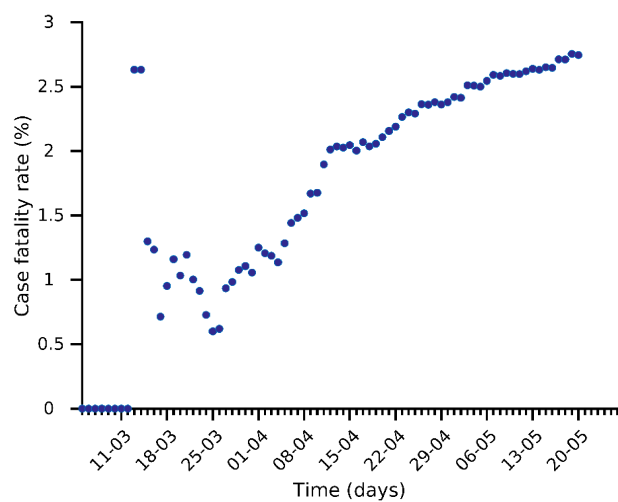
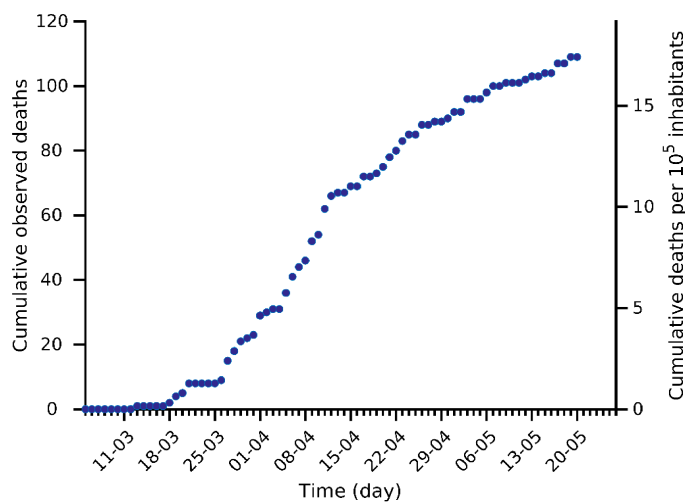
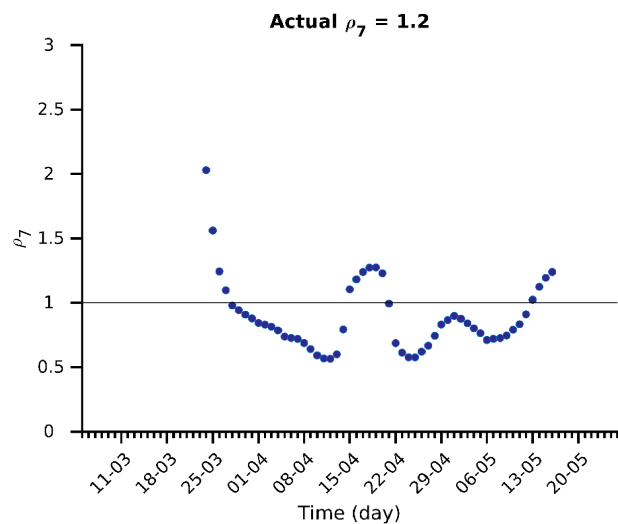
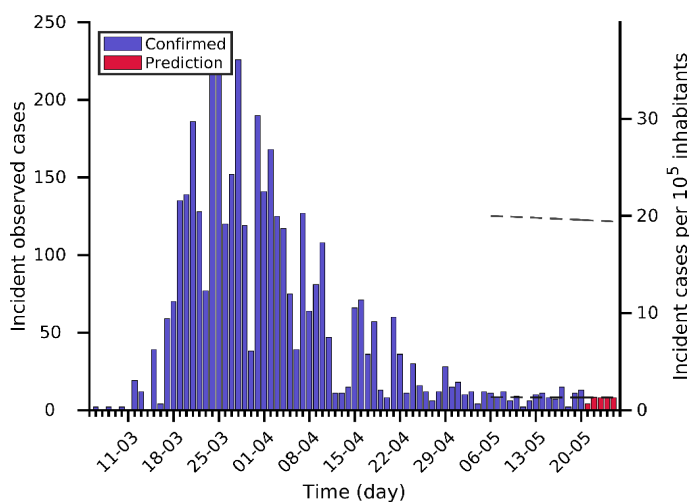
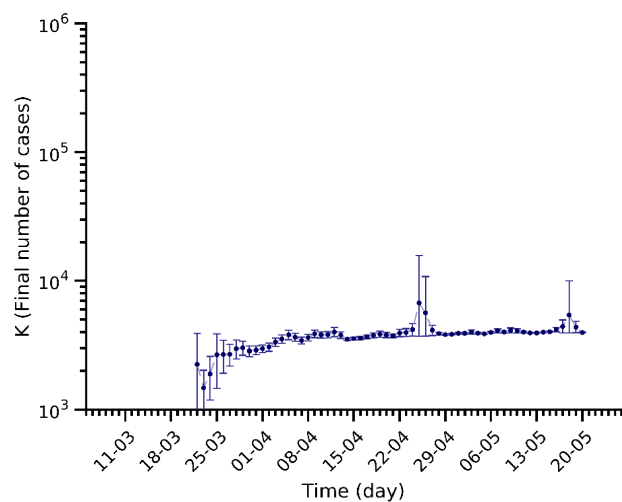
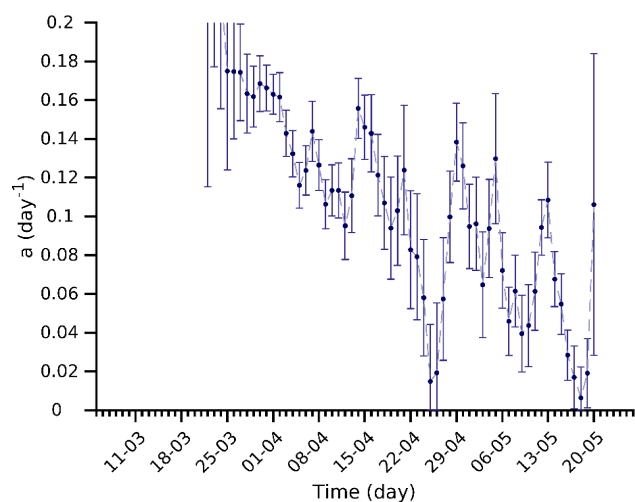
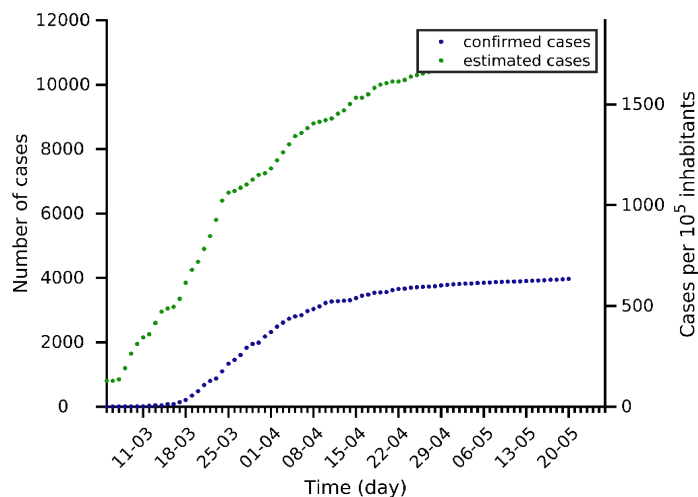
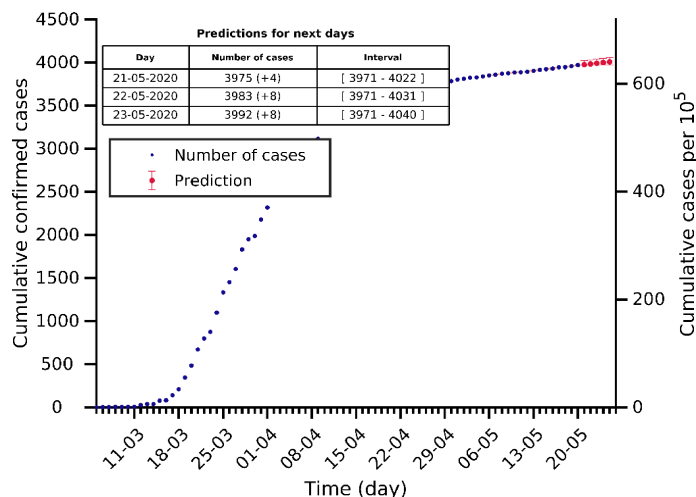




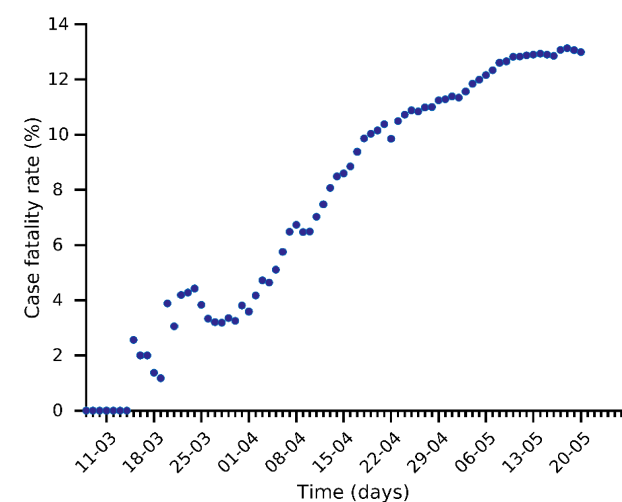
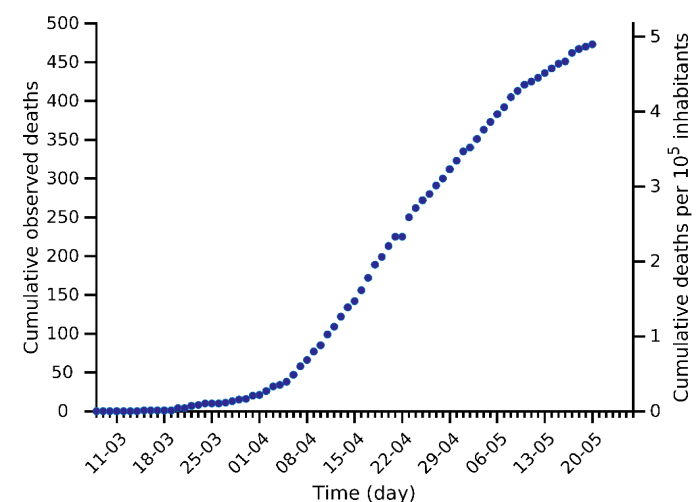
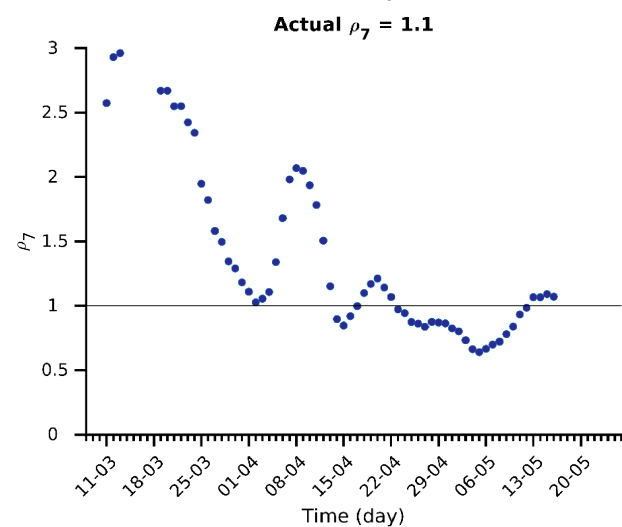
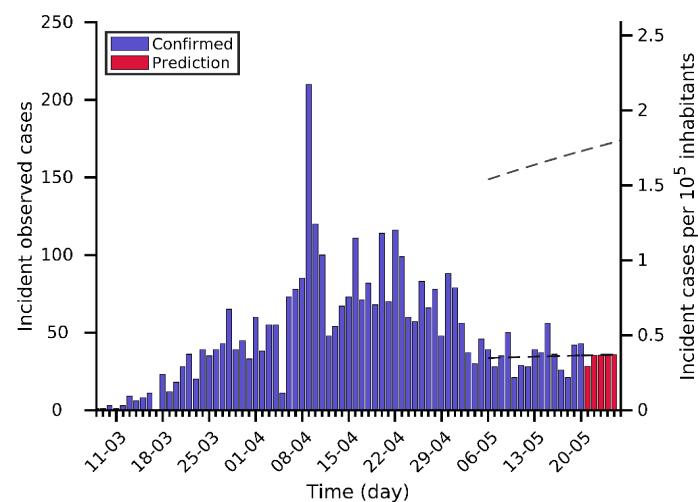
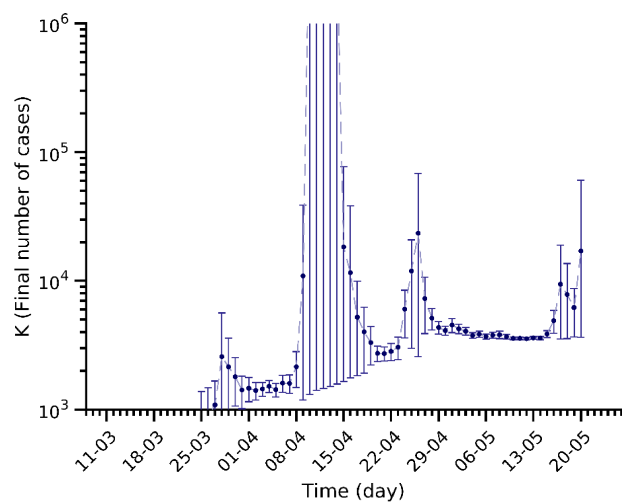
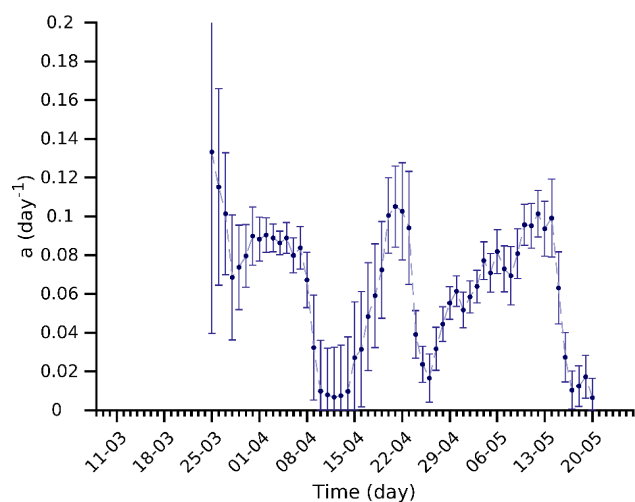
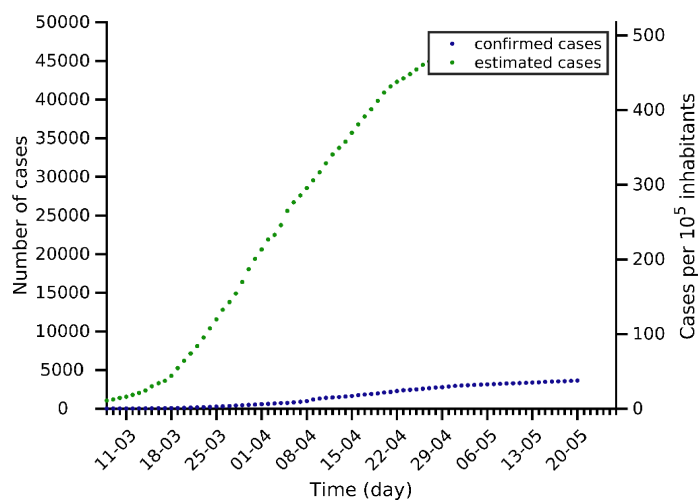
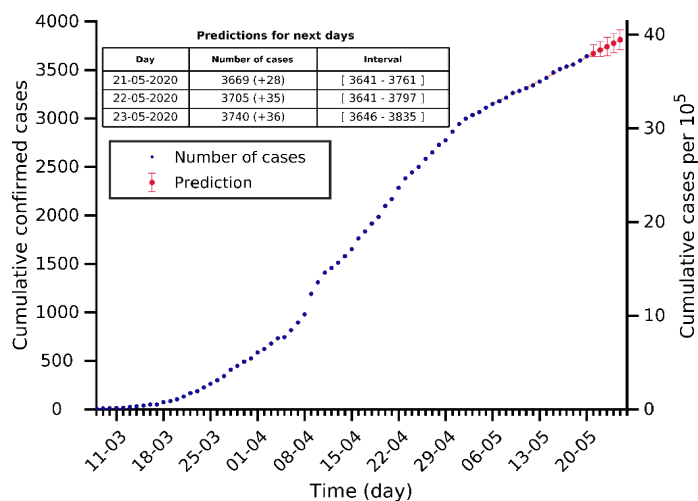
# Finland 20-05-2020. Population: 5.5M. Current cumulated incidence: 116/10<sup>5</sup>



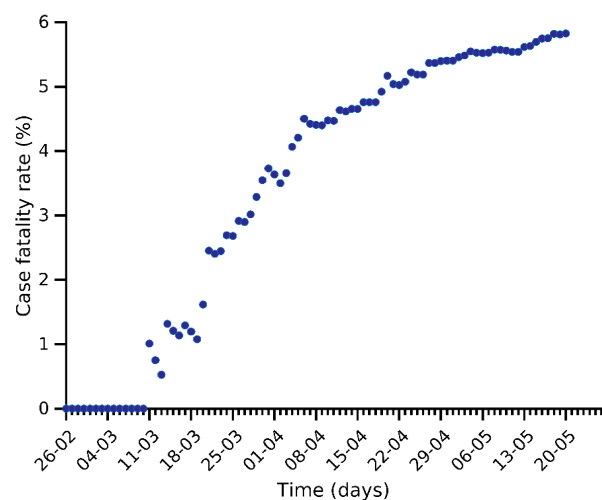
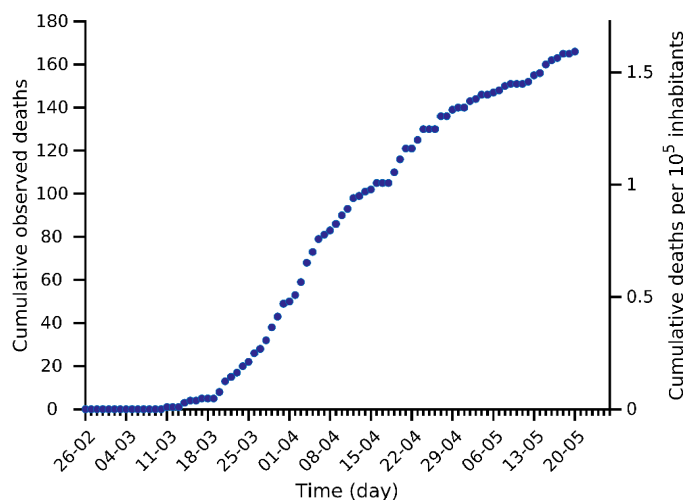
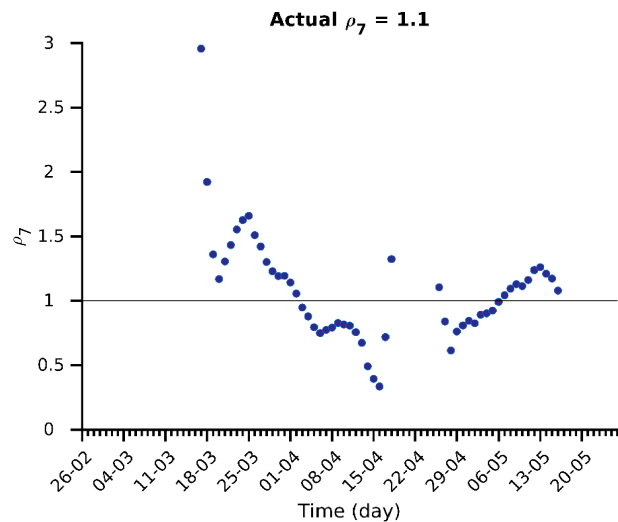
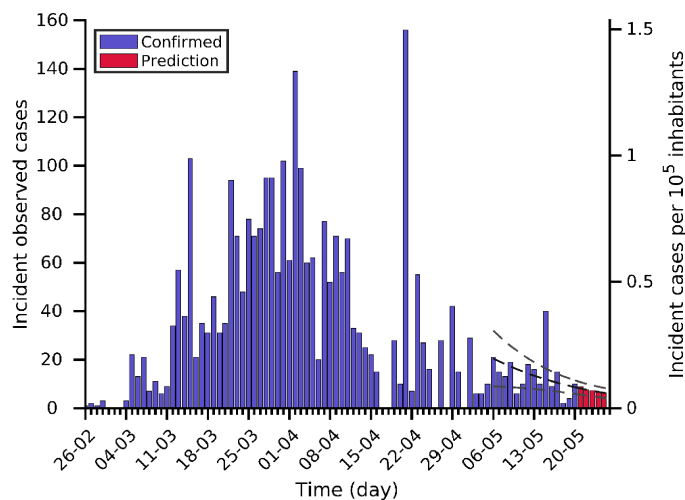
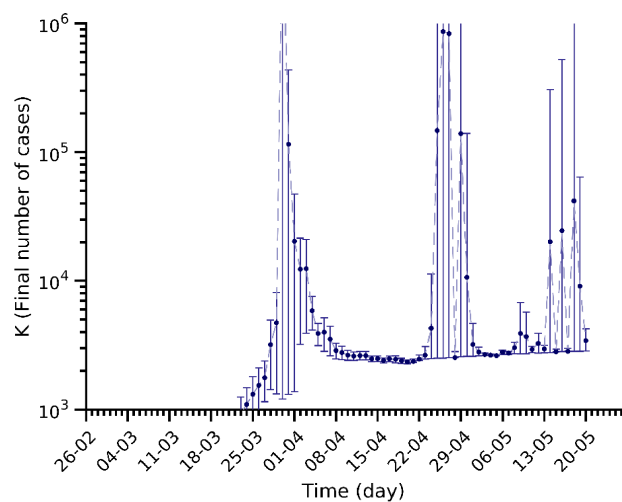
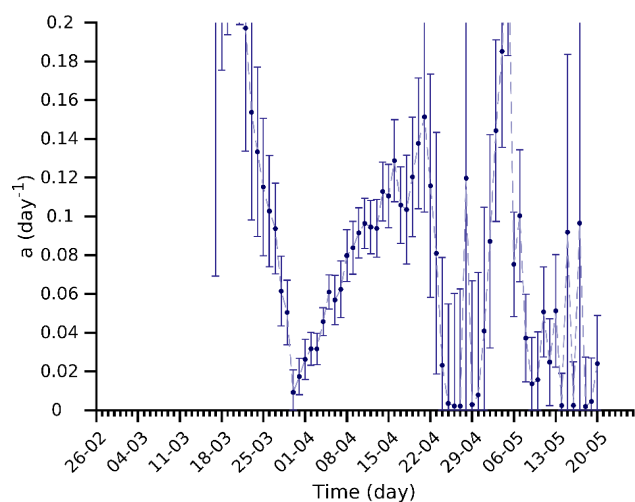
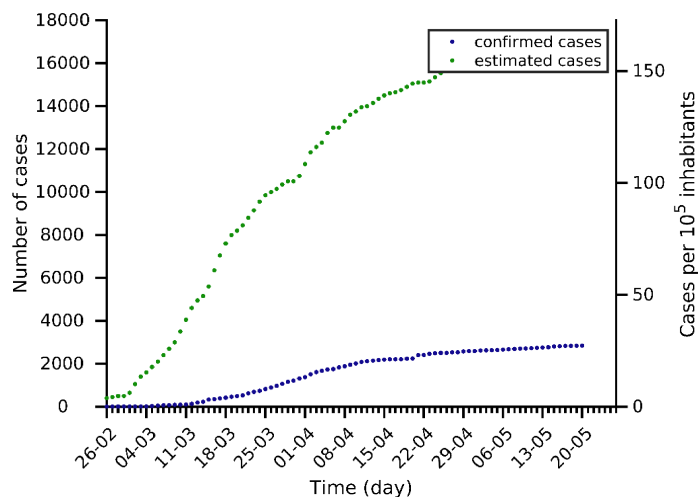
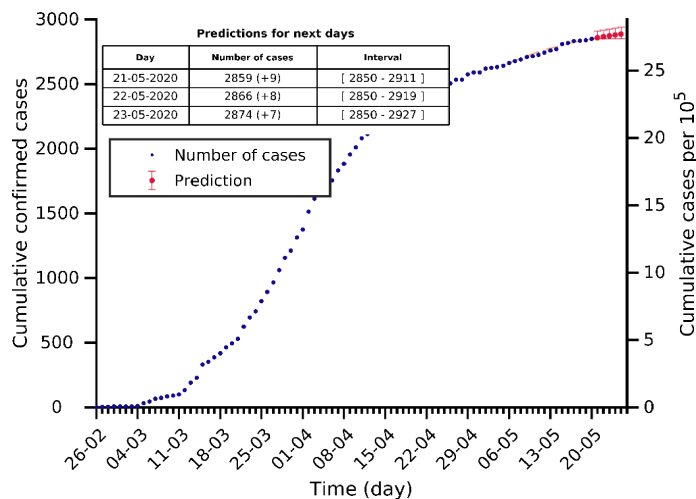
# Luxembourg 20-05-2020. Population: 0.6M. Current cumulated incidence: 634/10<sup>5</sup>



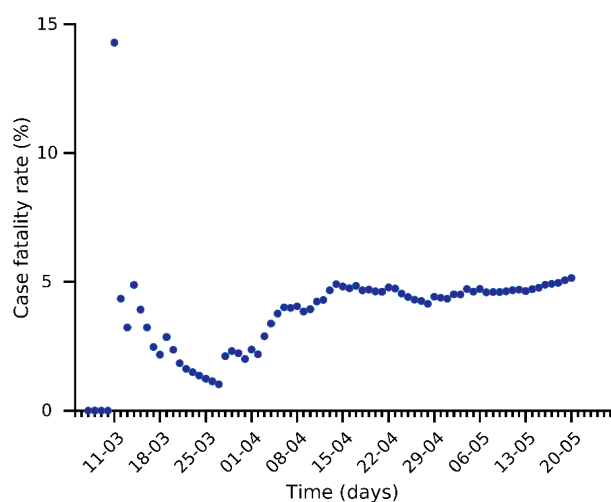
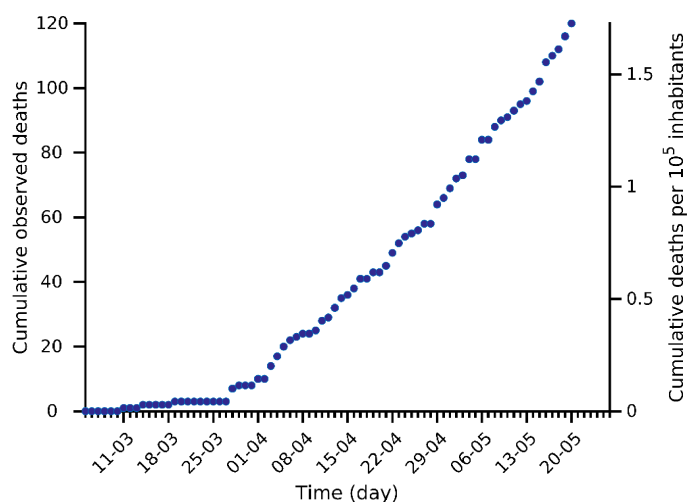
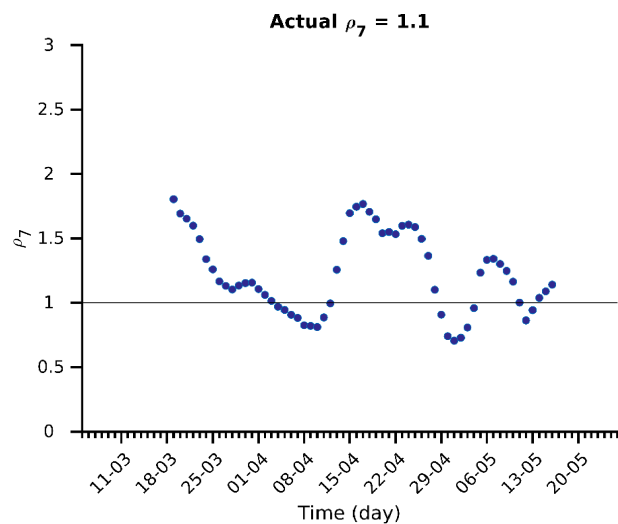
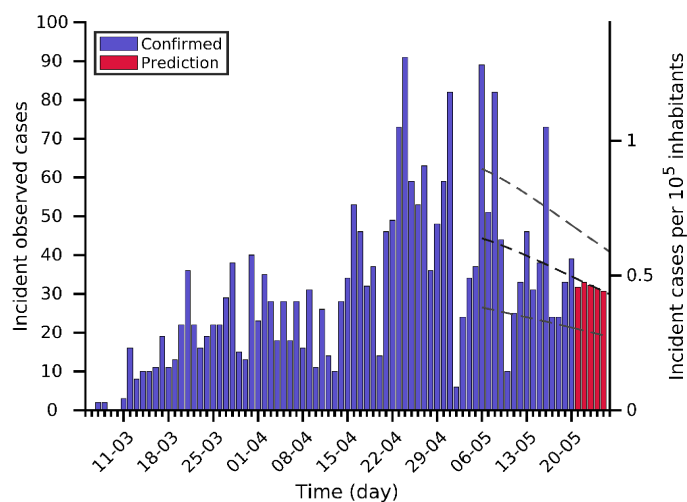
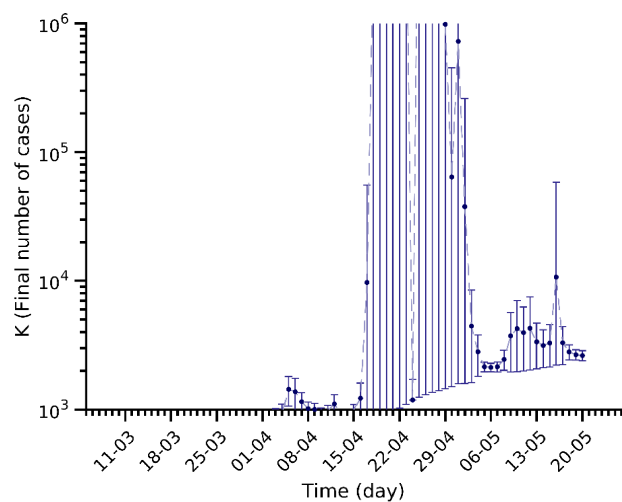
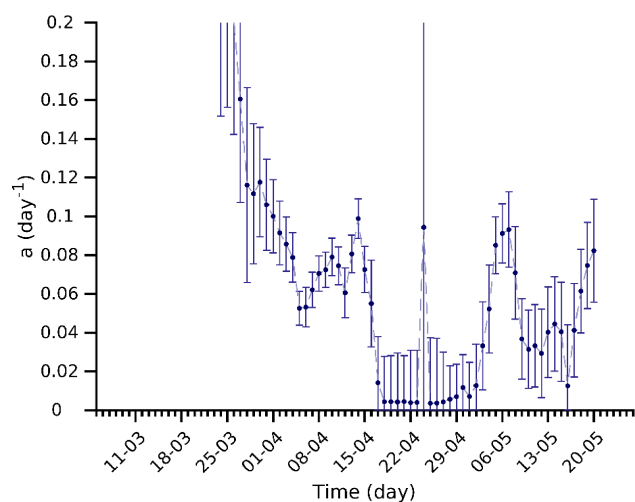
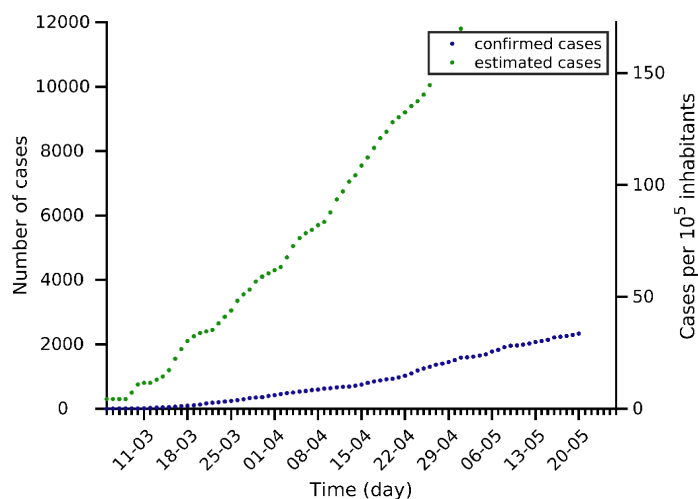
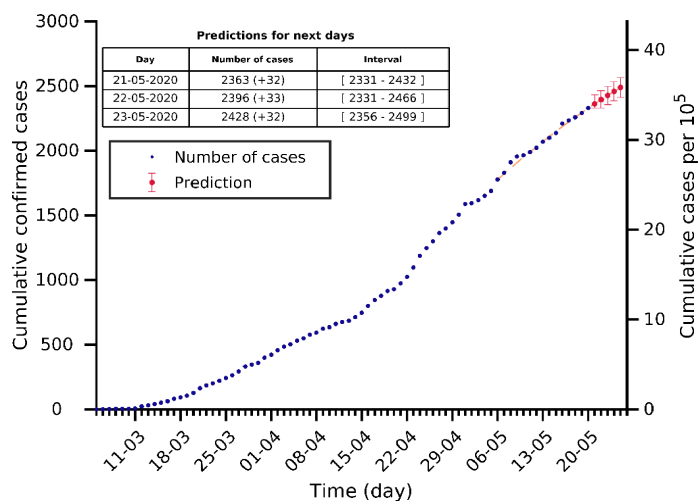
# Hungary 20-05-2020. Population: 9.7M. Current cumulated incidence: 38/10<sup>5</sup>



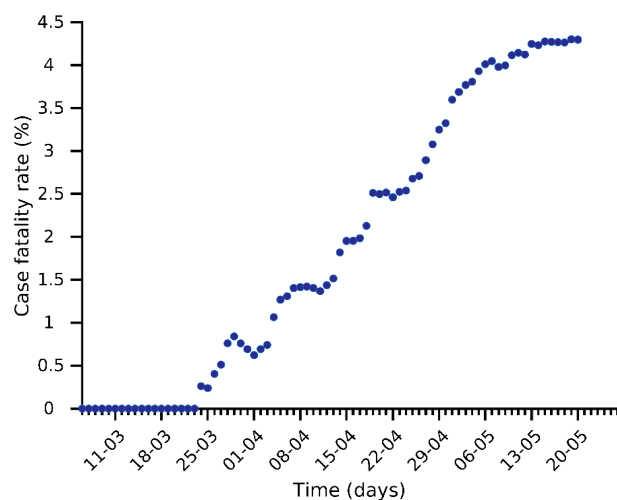
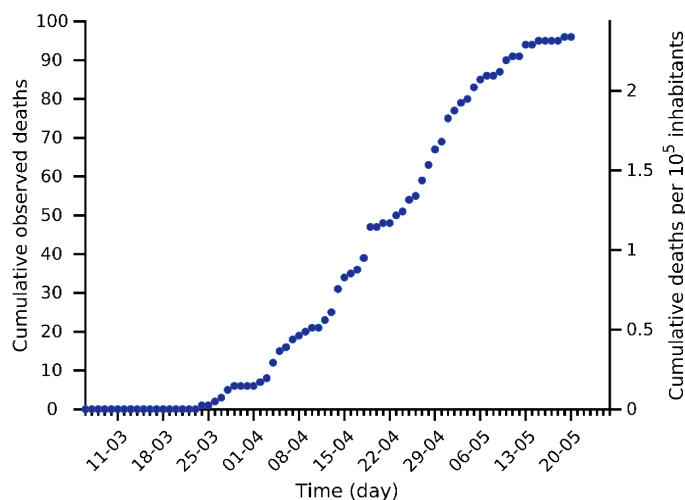
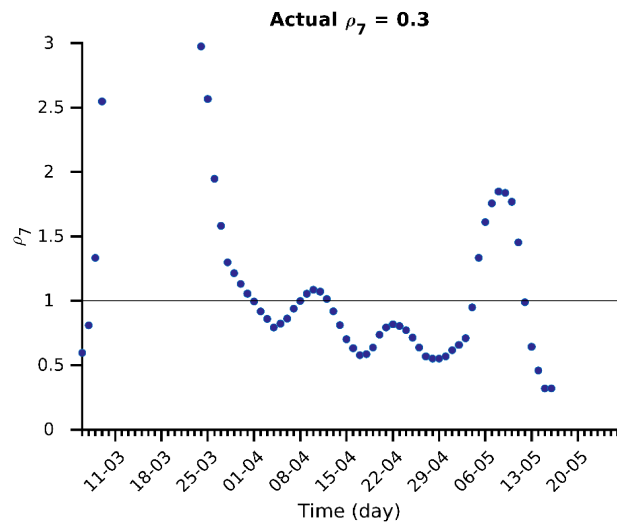
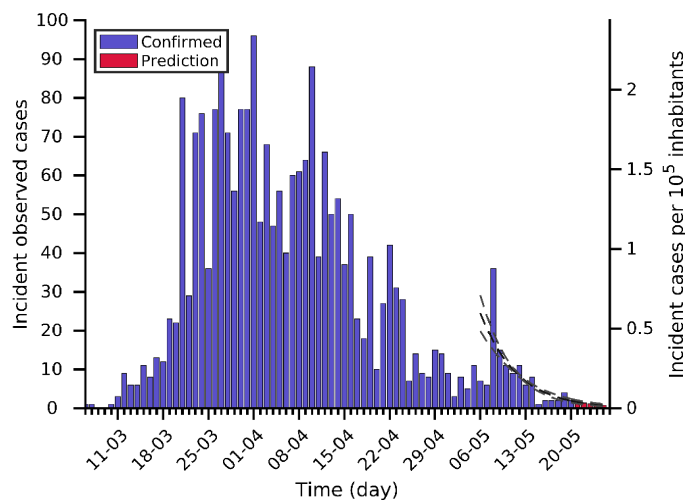
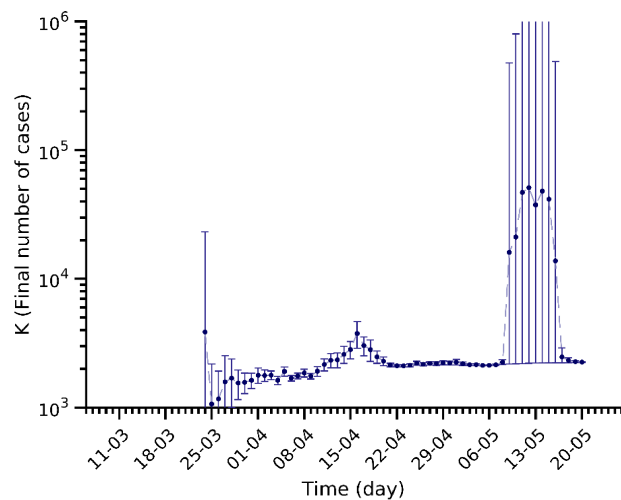
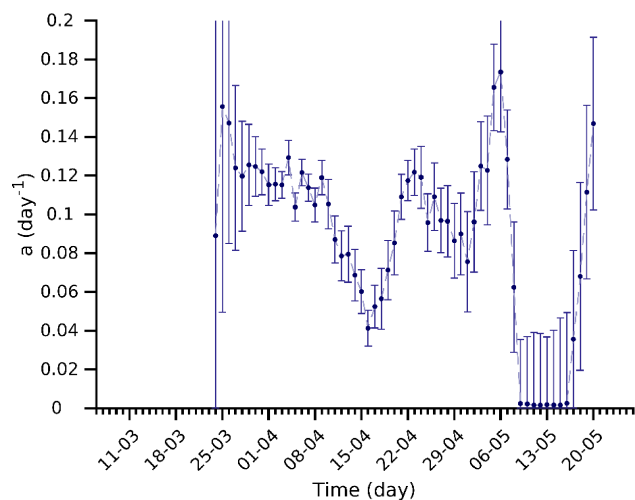
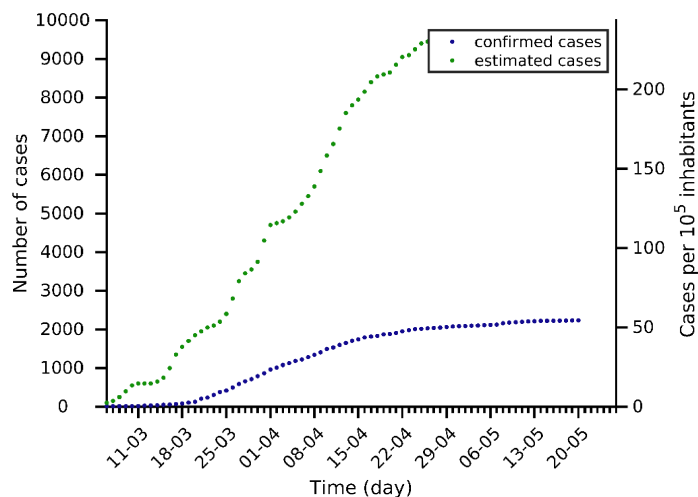
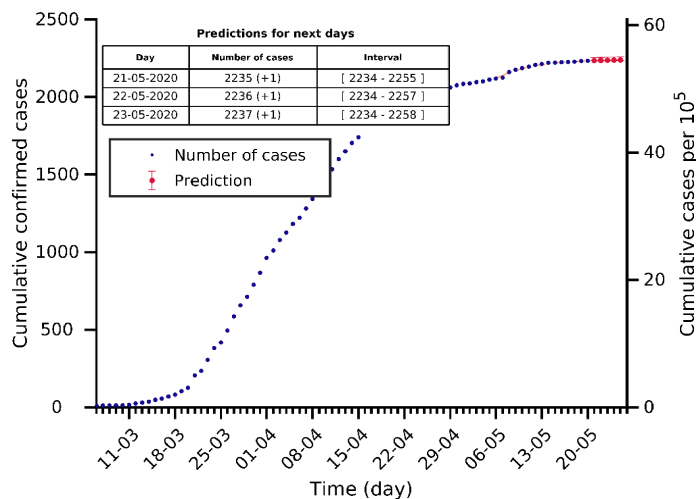
# Greece 20-05-2020. Population: 10.4M. Current cumulated incidence: 27/10<sup>5</sup>



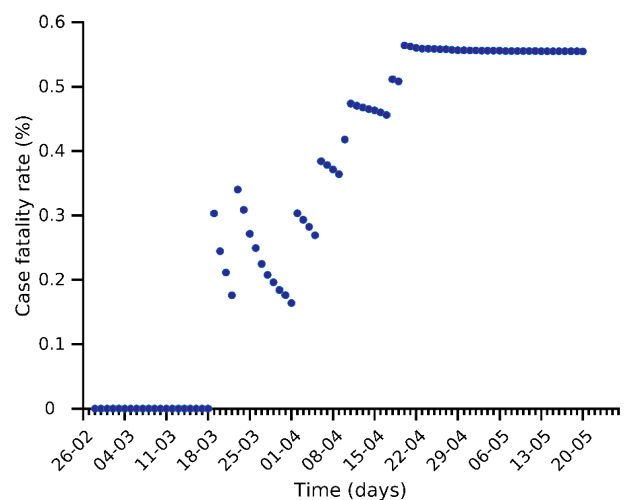
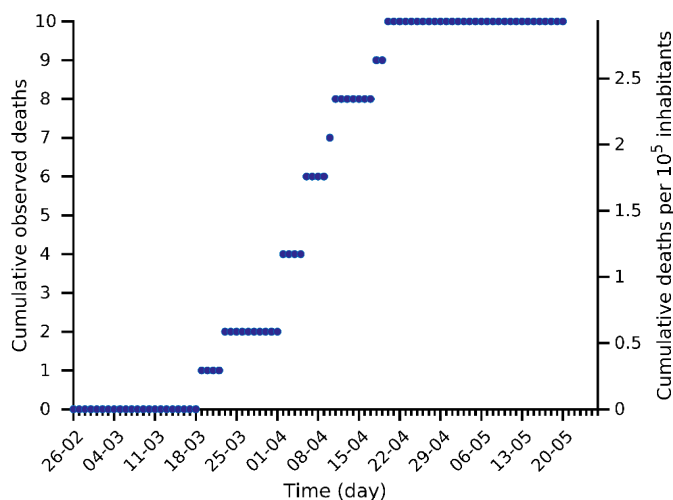
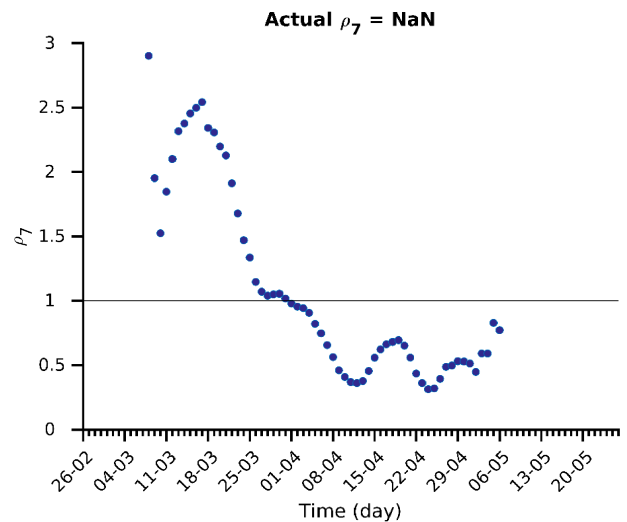
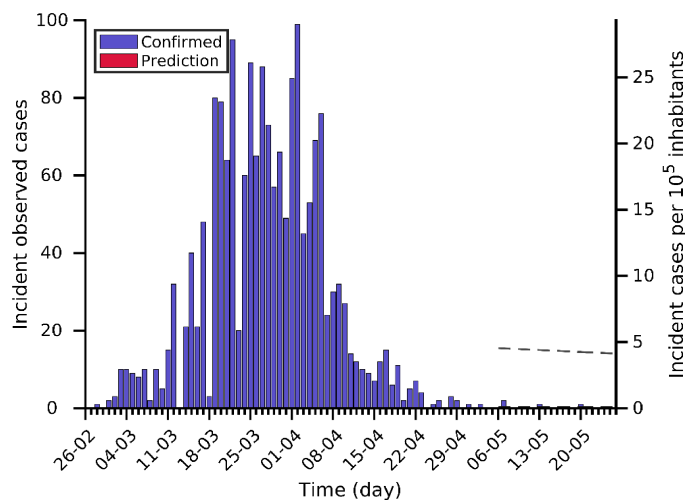
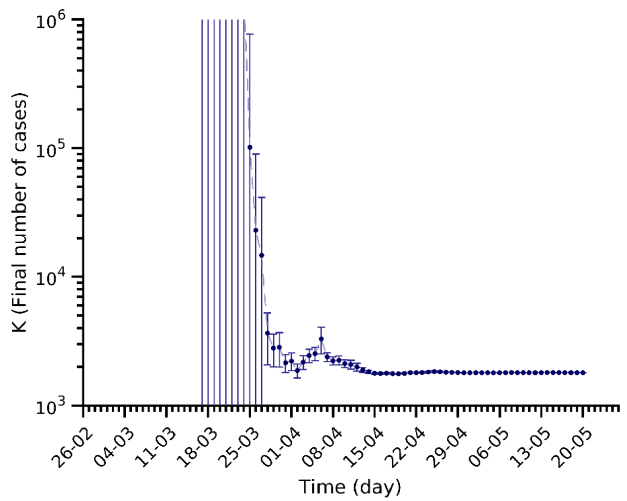
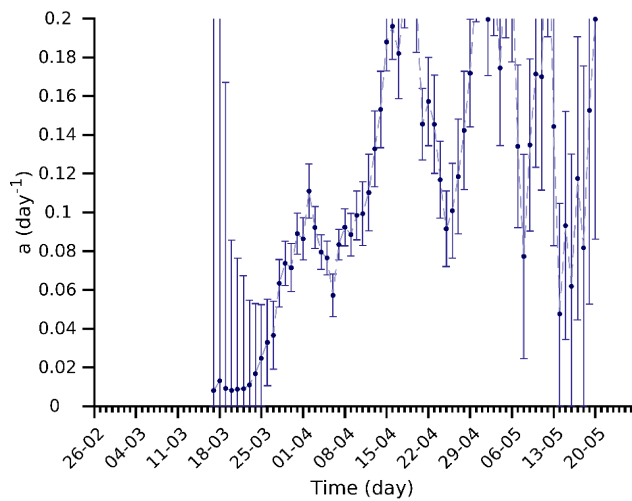
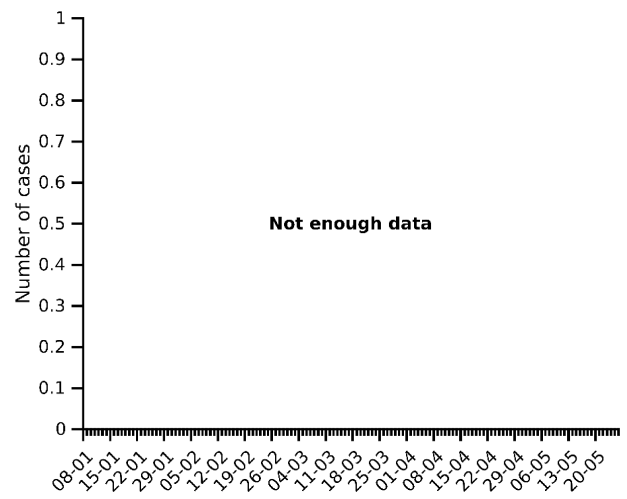
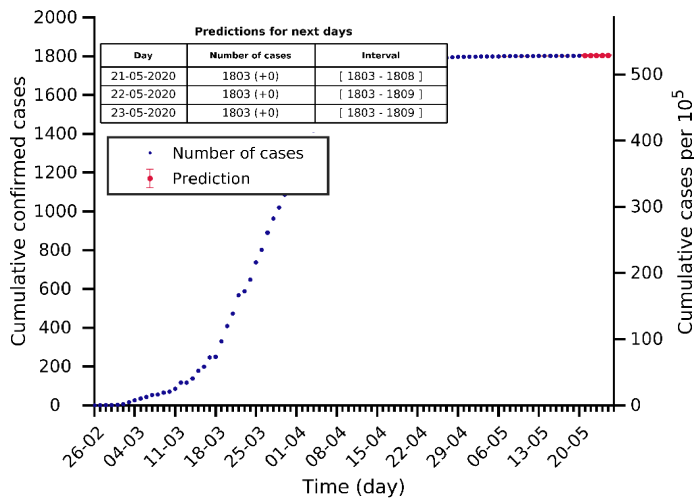
# Bulgaria 20-05-2020. Population: 6.9M. Current cumulated incidence: 34/10<sup>5</sup>



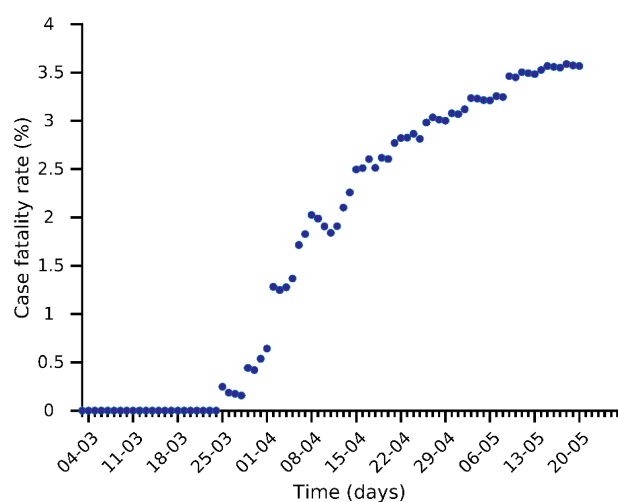
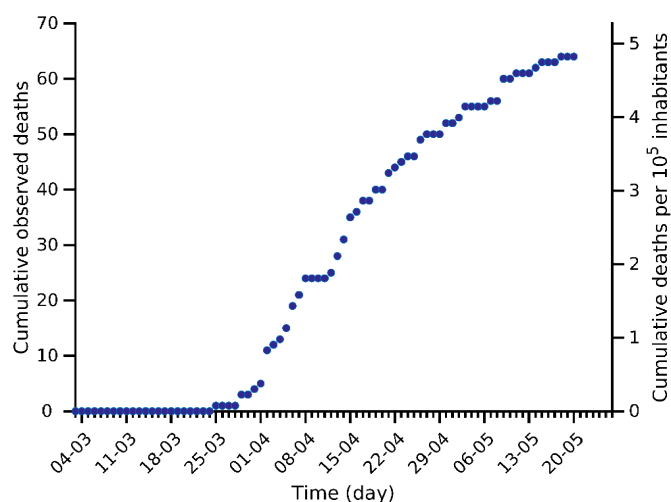
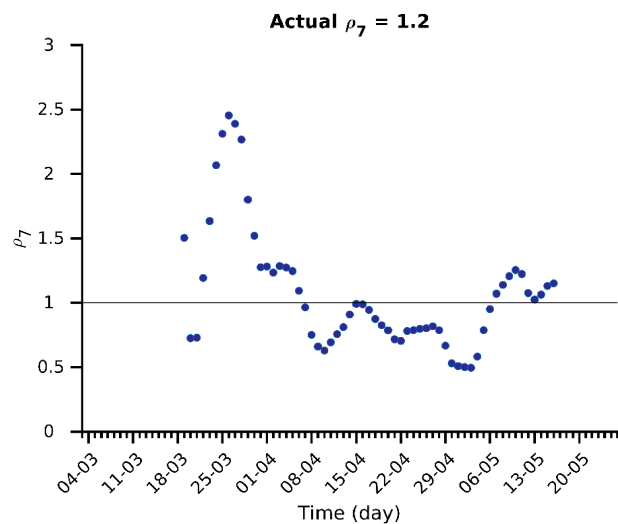
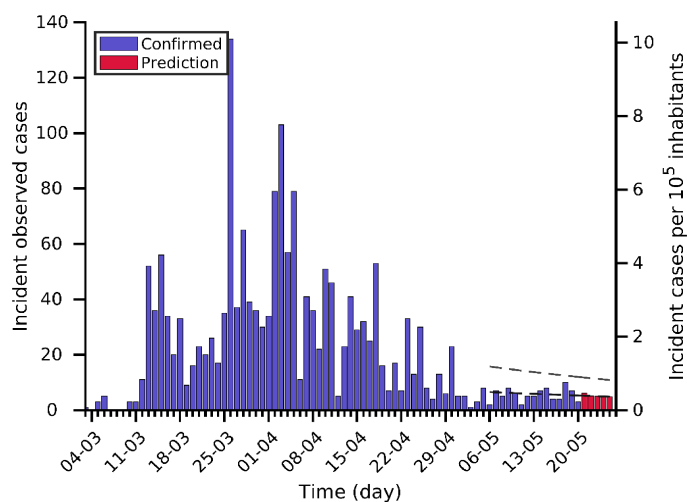
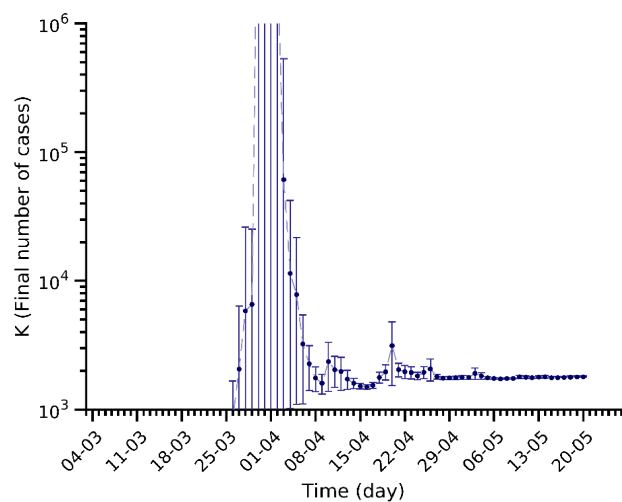
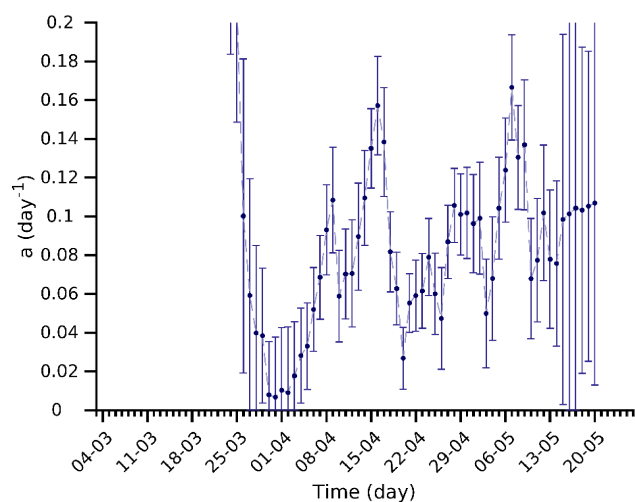
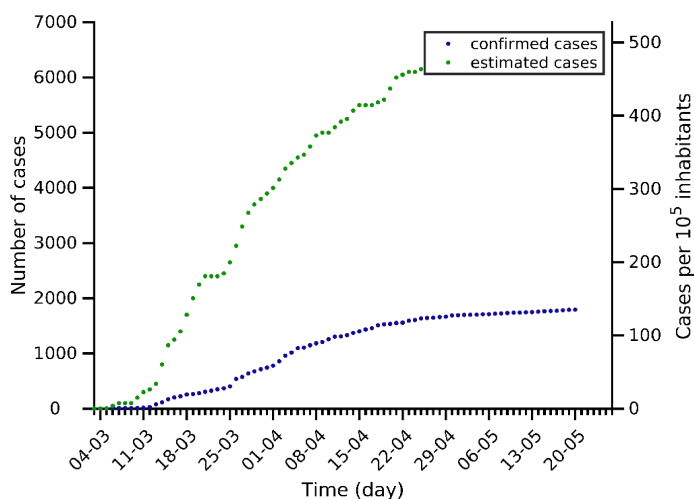
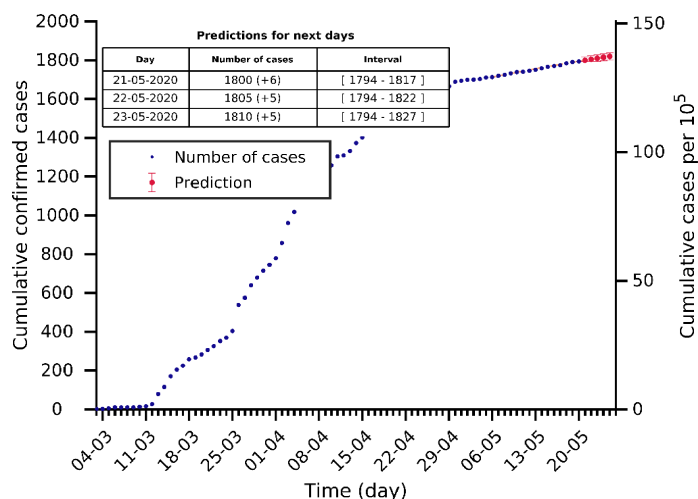
# Croatia 20-05-2020. Population: 4.1M. Current cumulated incidence: 54/10<sup>5</sup>



# Iceland 20-05-2020. Population: 0.3M. Current cumulated incidence: 528/10<sup>5</sup>

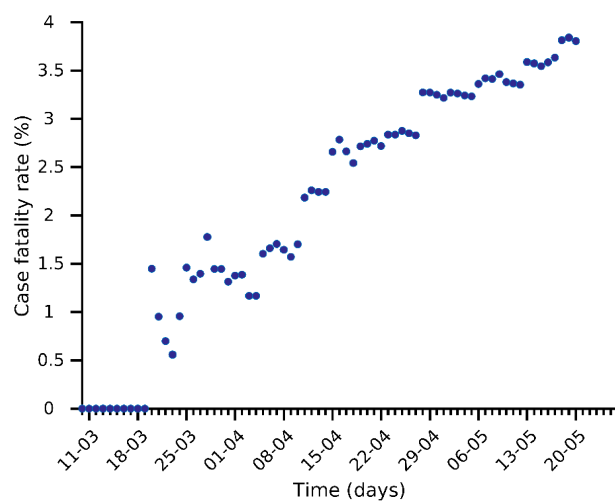
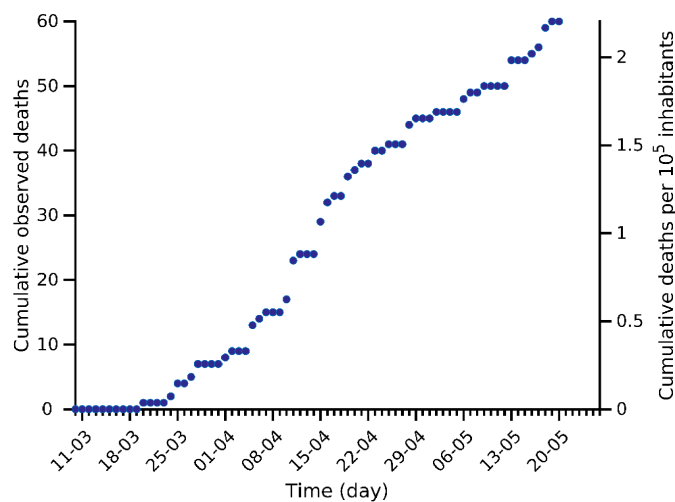
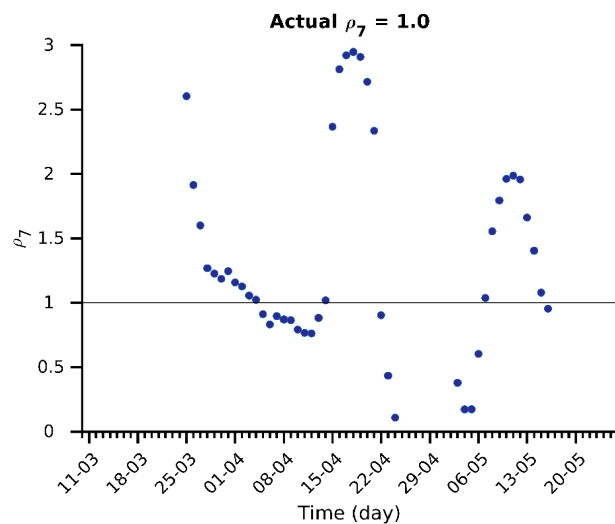
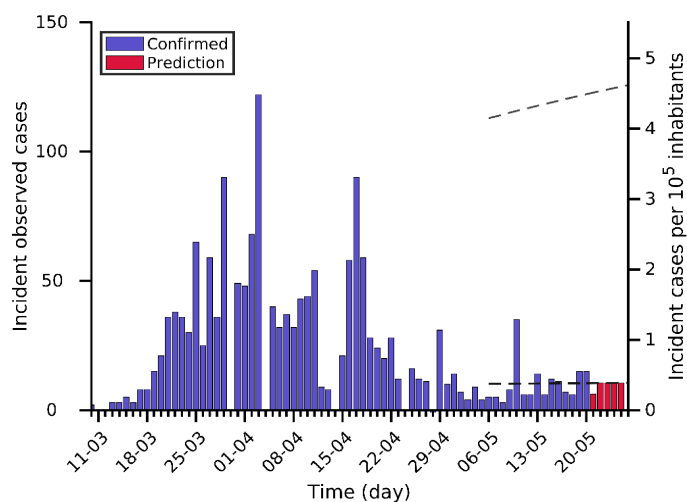
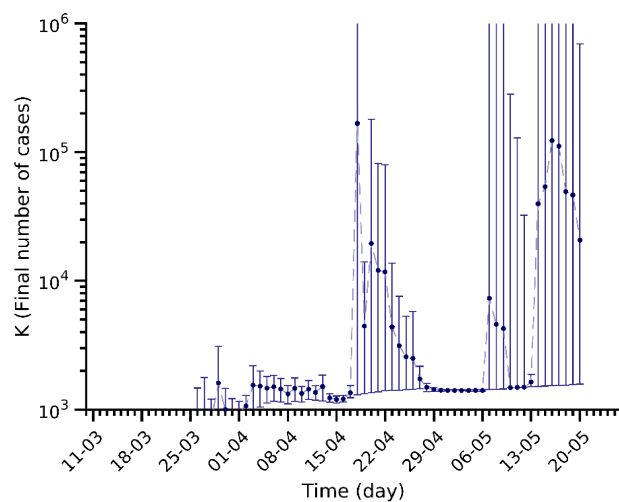
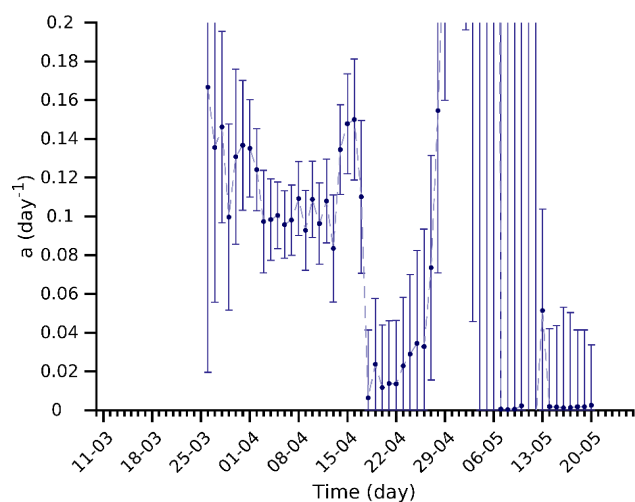
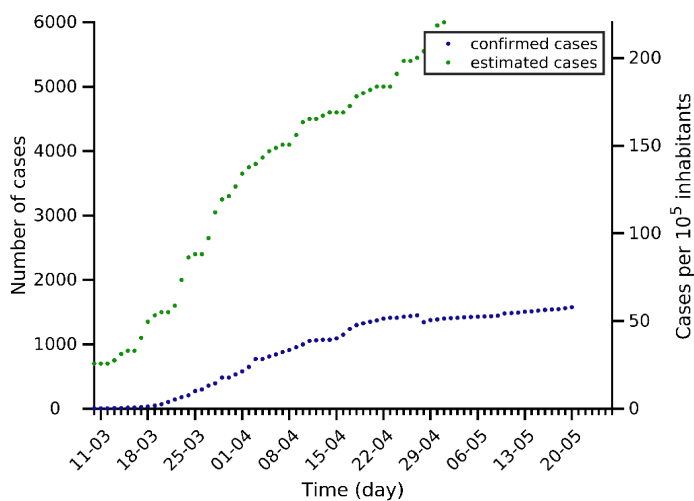
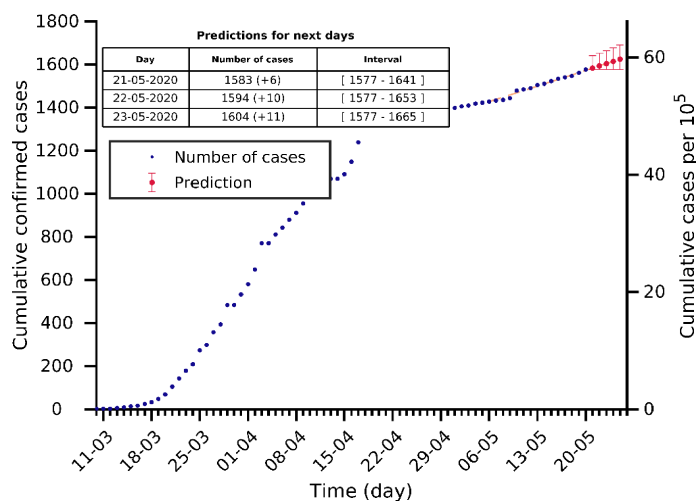


# Estonia 20-05-2020. Population: 1.3M. Current cumulated incidence: 135/10<sup>5</sup>

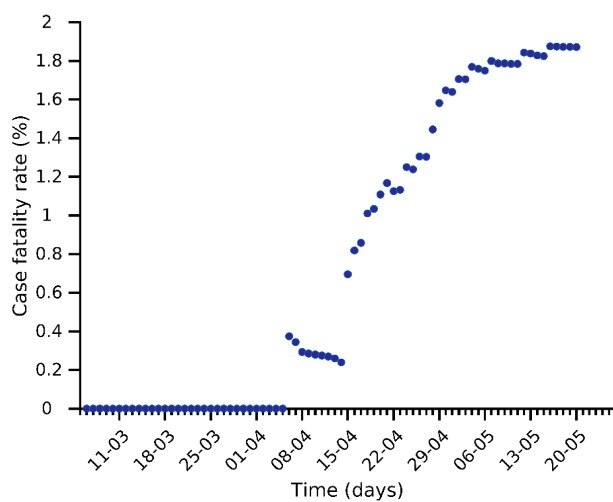
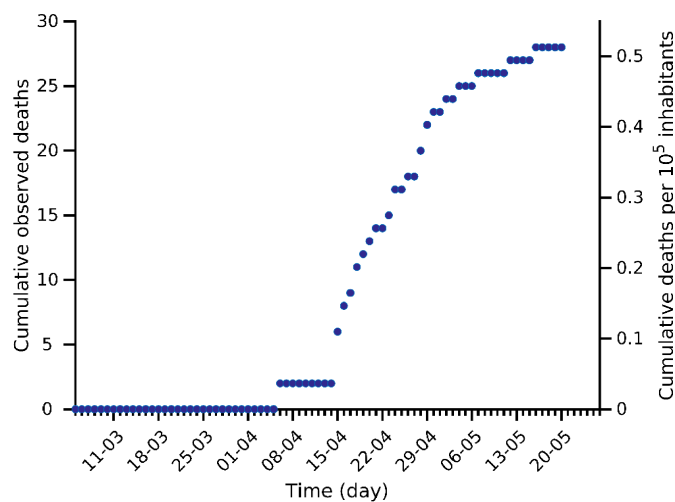
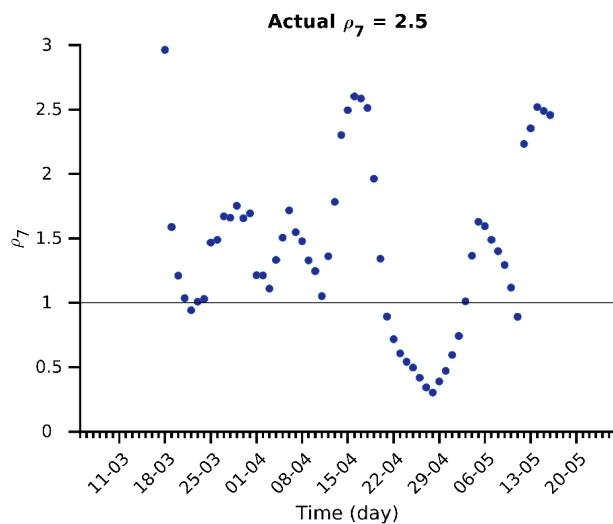
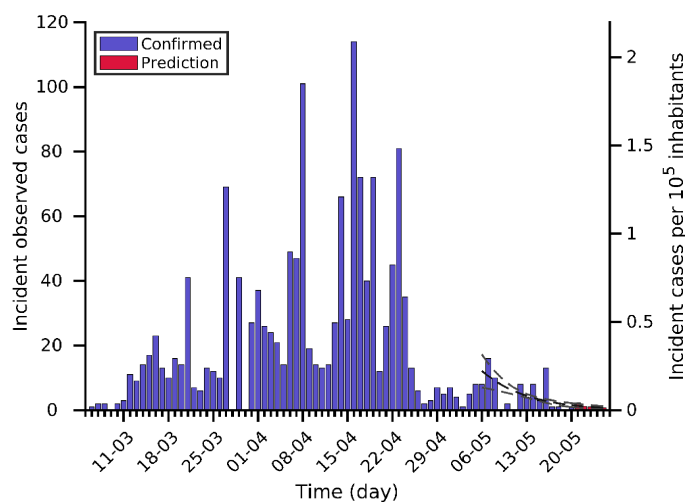
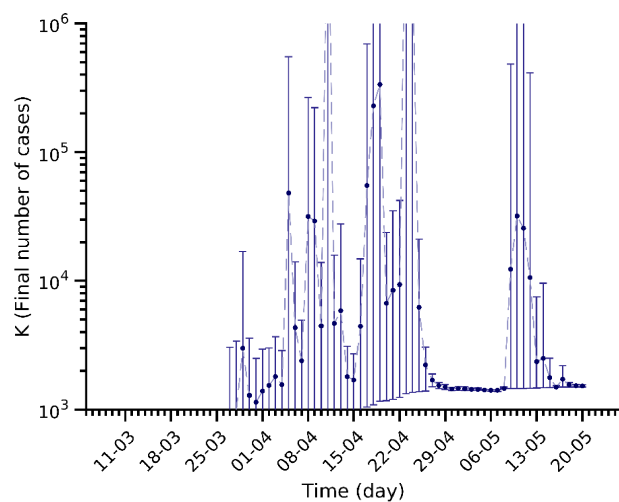
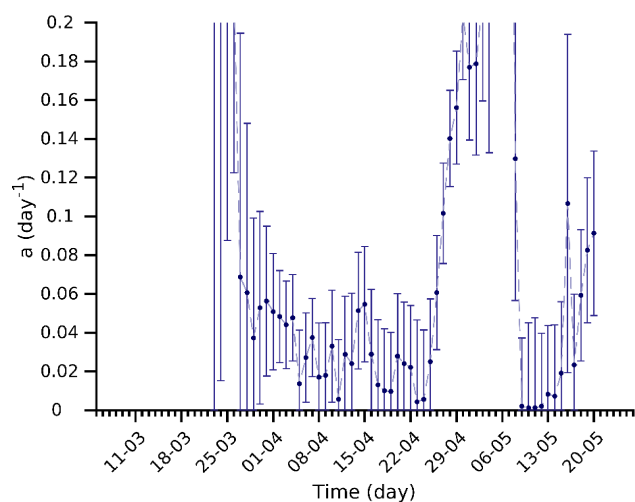
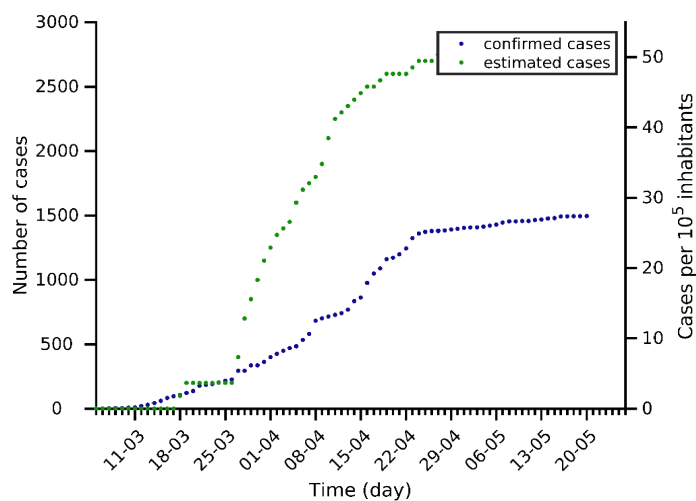
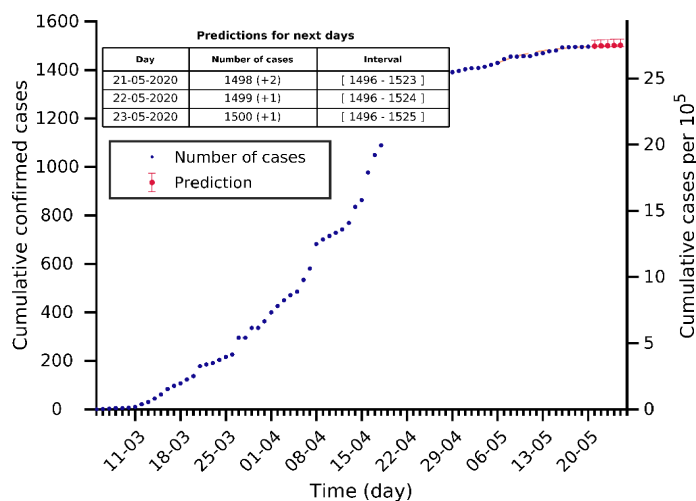




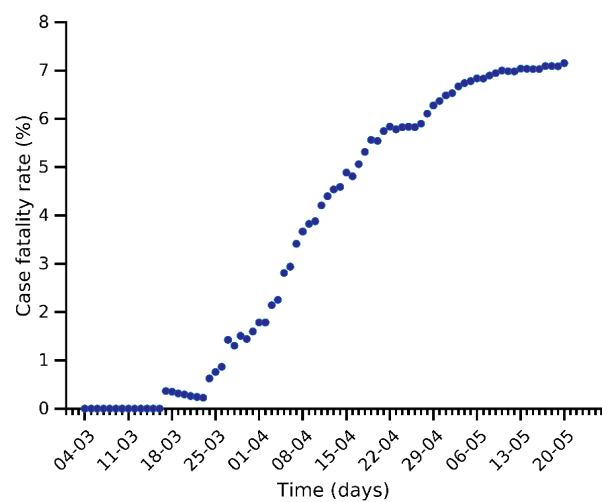
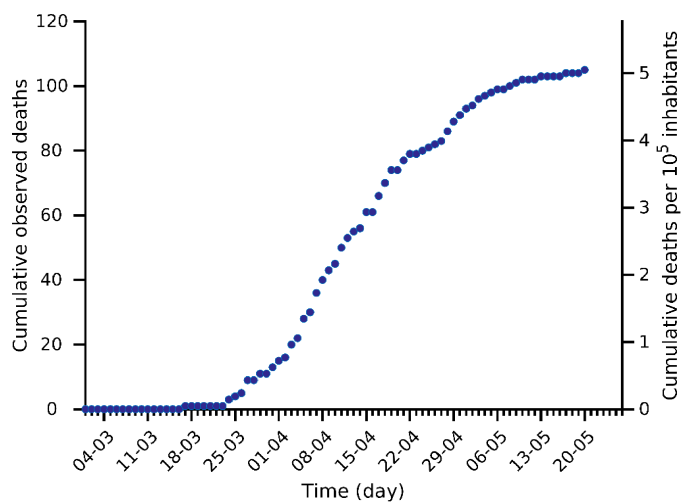
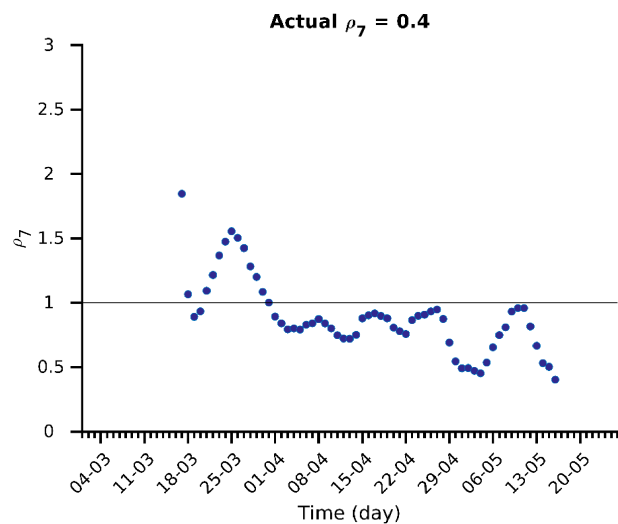
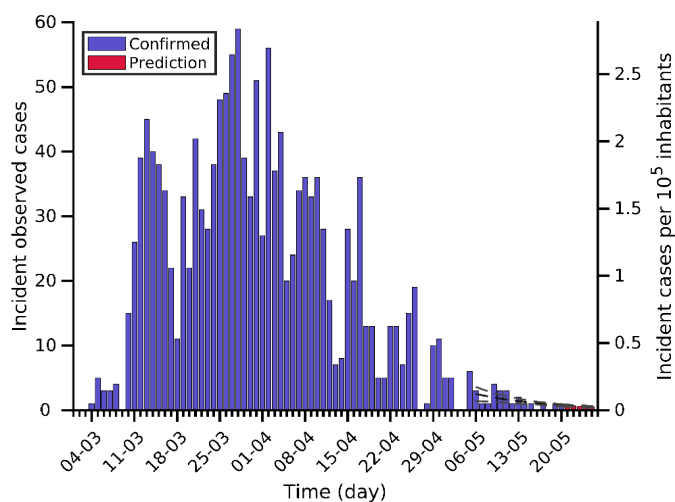
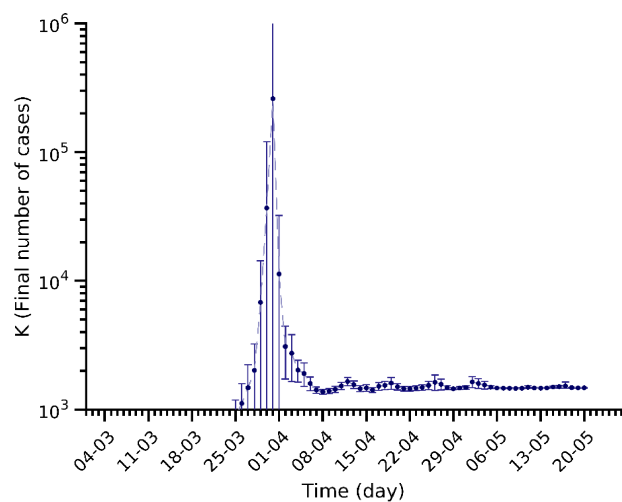
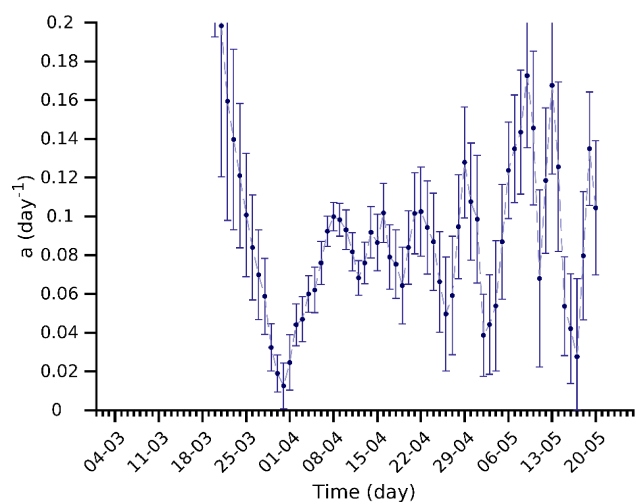
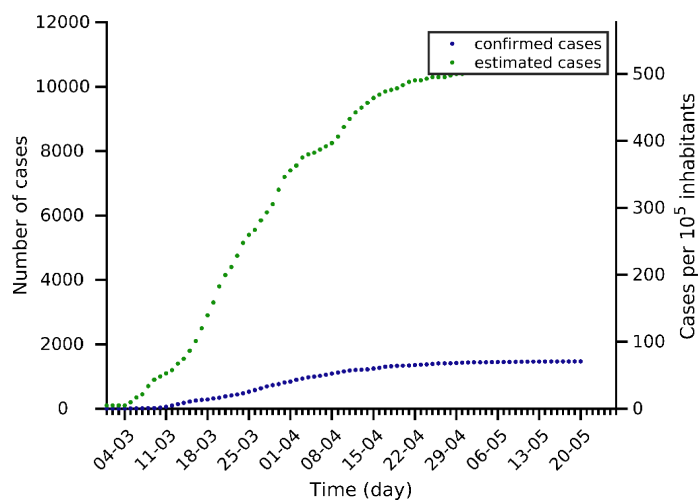
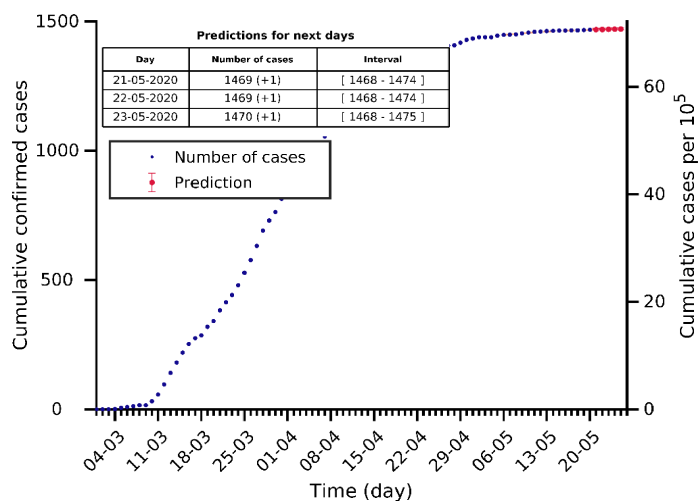
# Lithuania 20-05-2020. Population: 2.7M. Current cumulated incidence: 58/10<sup>5</sup>



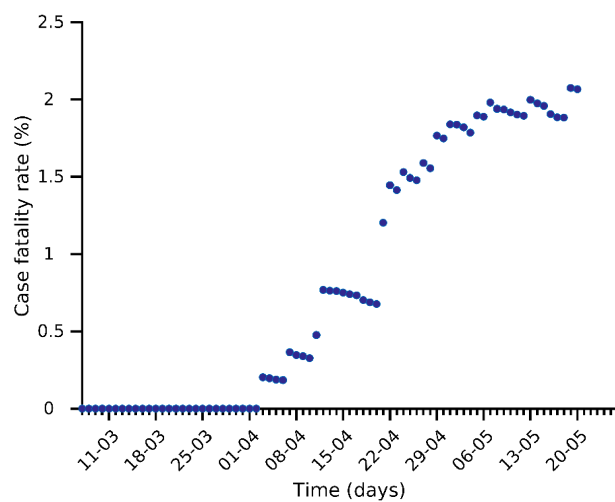
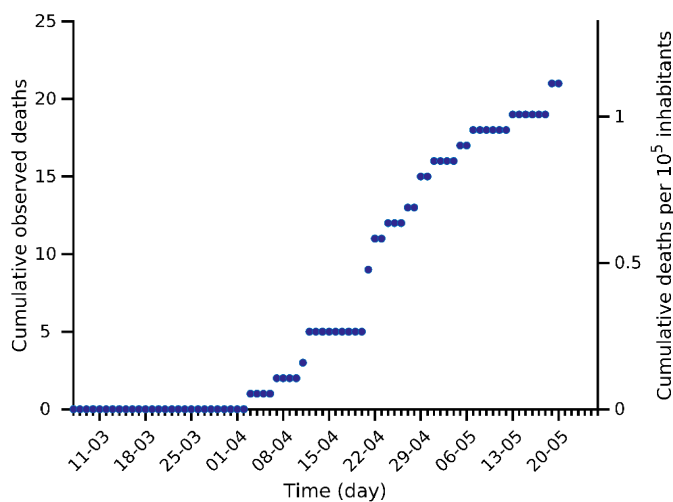
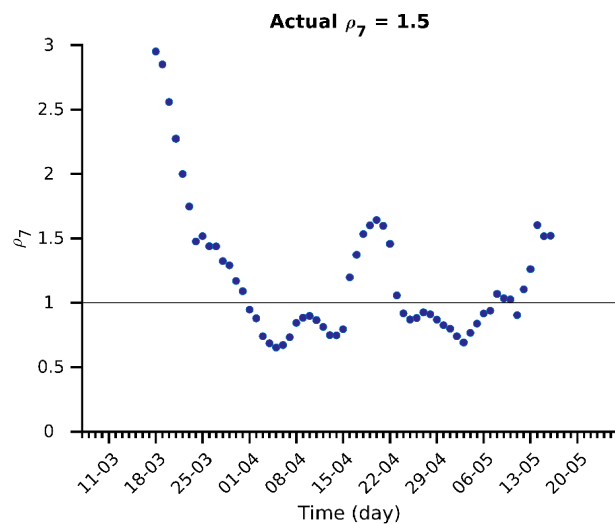
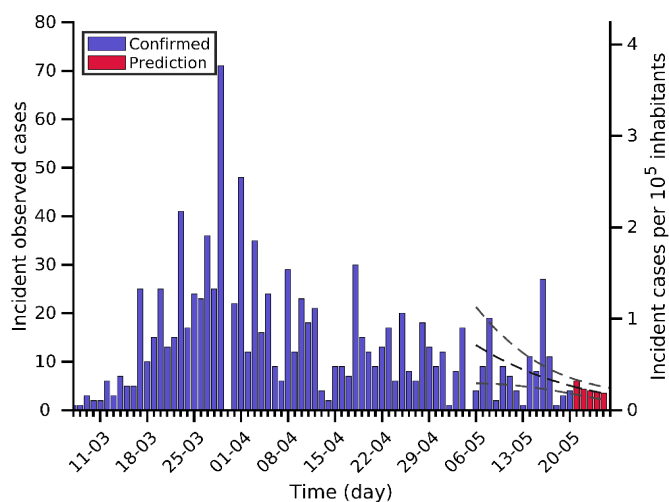
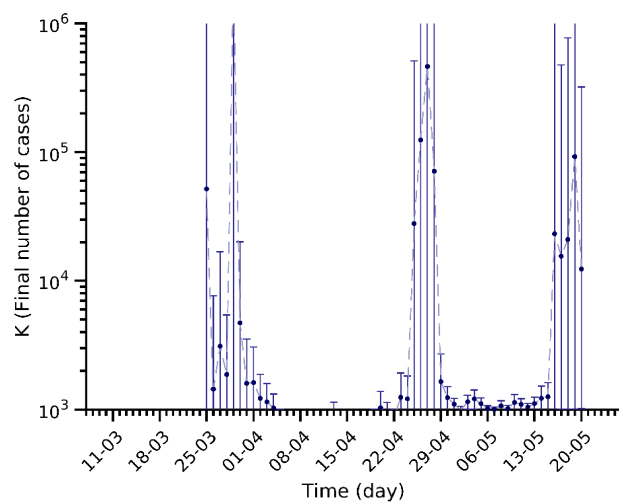
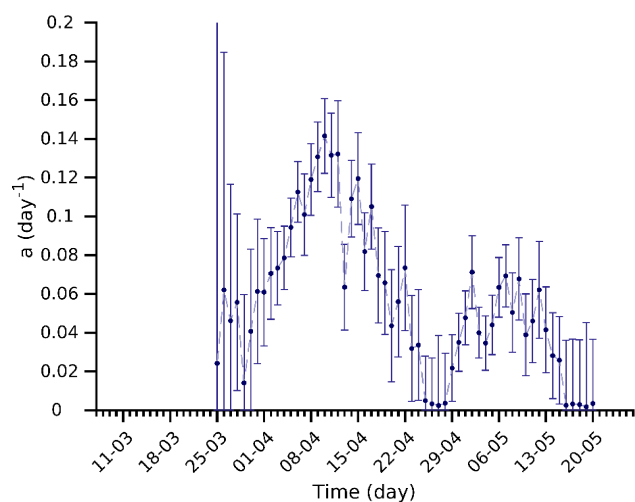
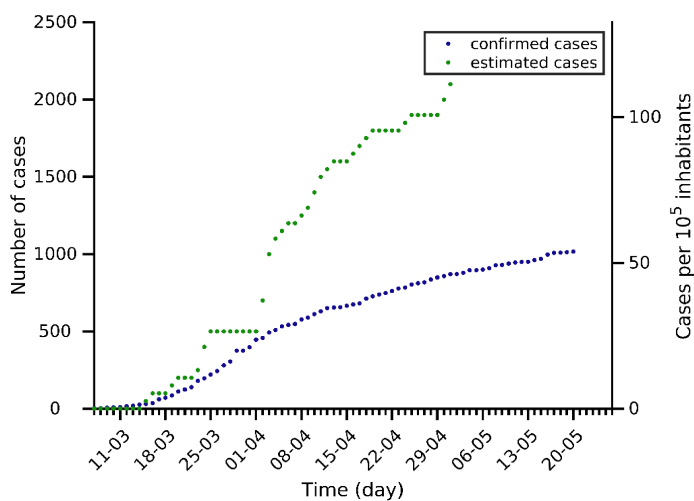
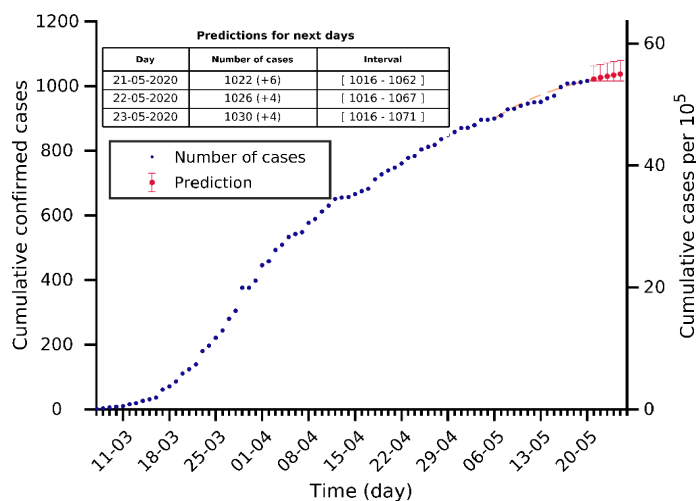
# Slovakia 20-05-2020. Population: 5.5M. Current cumulated incidence: $27/10^5$



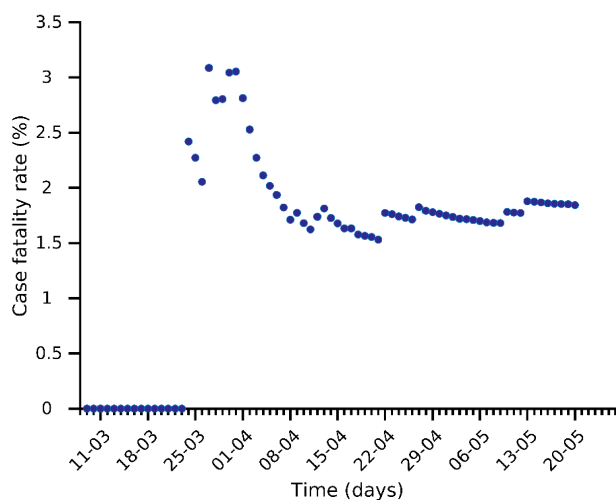
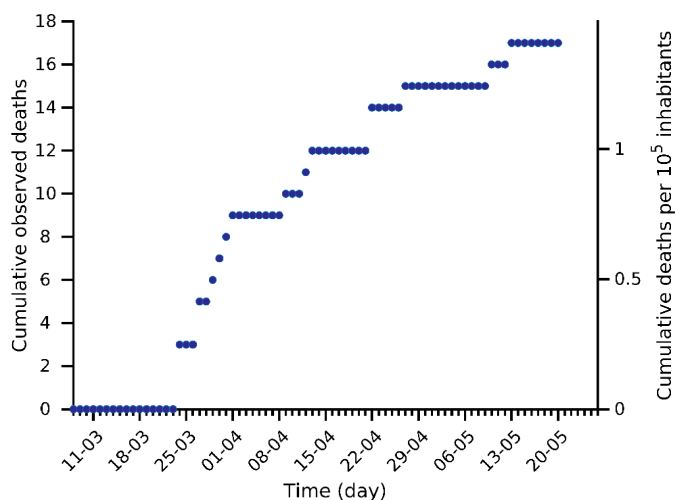
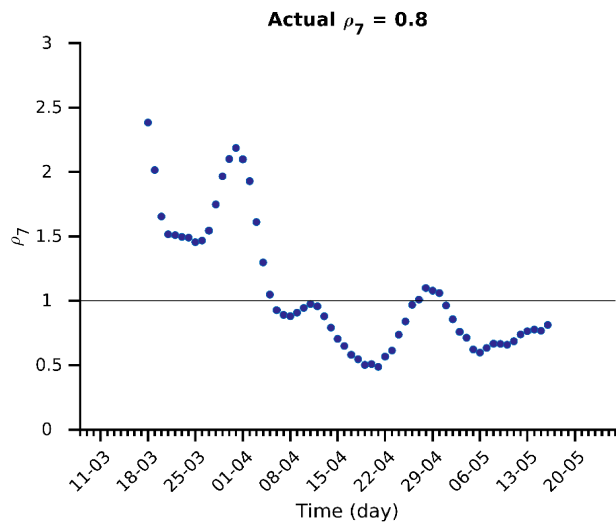
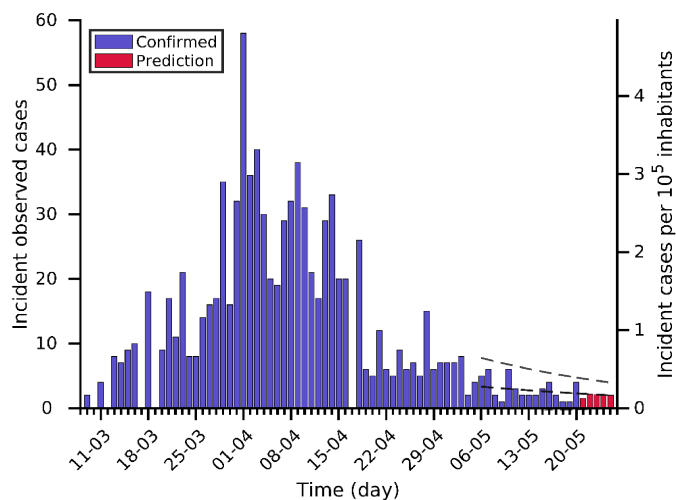
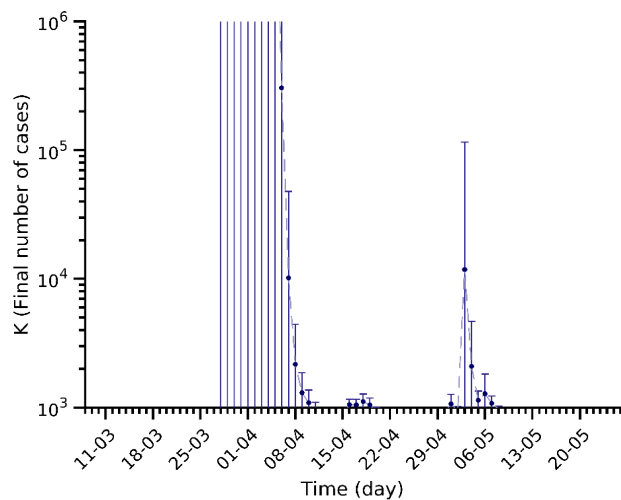
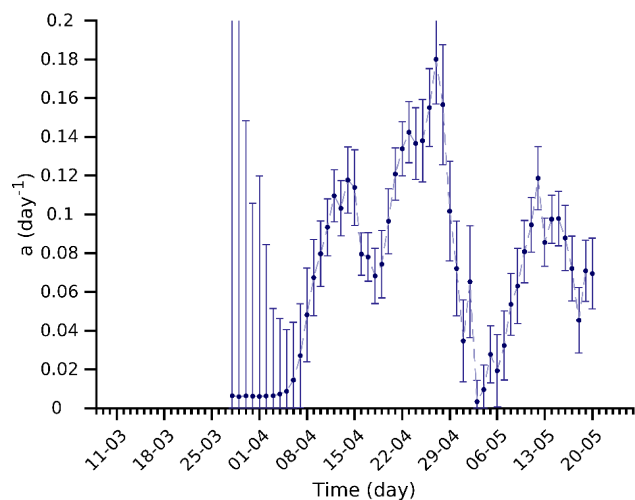
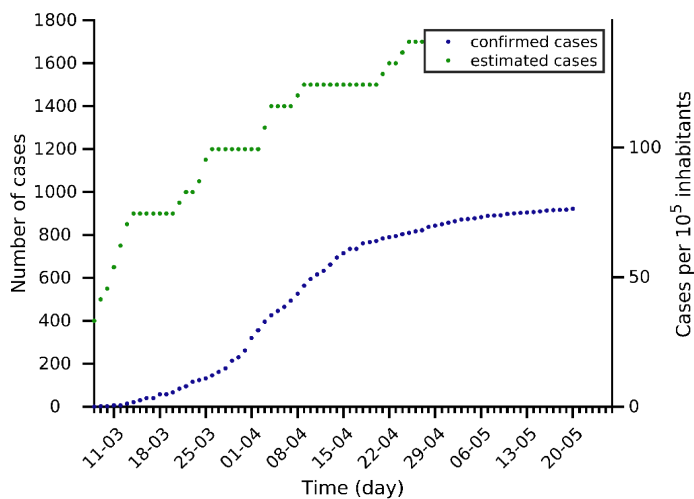
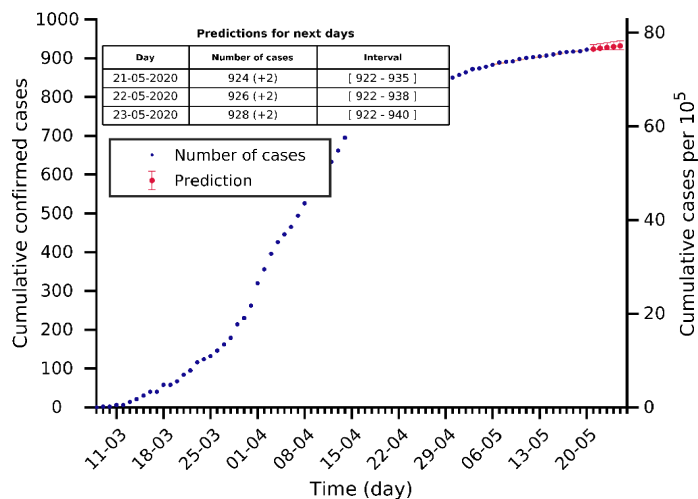
# Slovenia 20-05-2020. Population: 2.1M. Current cumulated incidence: 71/10<sup>5</sup>



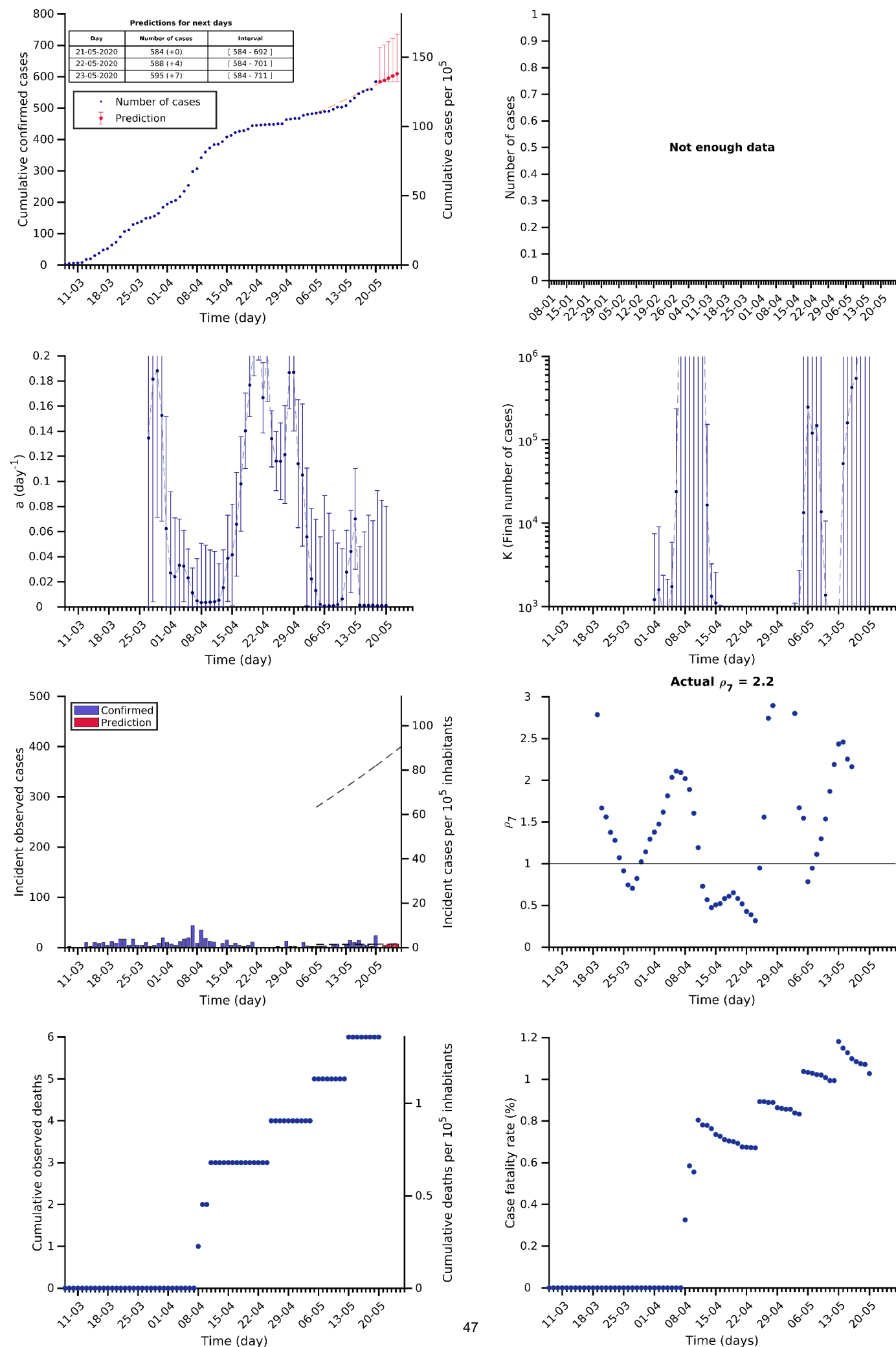
# Latvia 20-05-2020. Population: 1.9M. Current cumulated incidence: 54/10<sup>5</sup>



# Cyprus 20-05-2020. Population: 1.2M. Current cumulated incidence: 76/10<sup>5</sup>



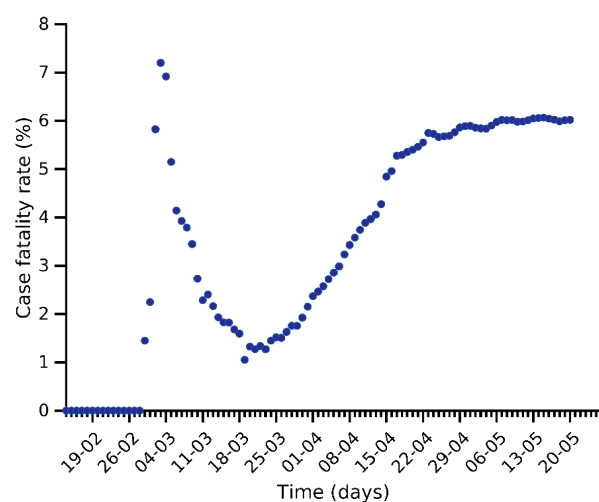
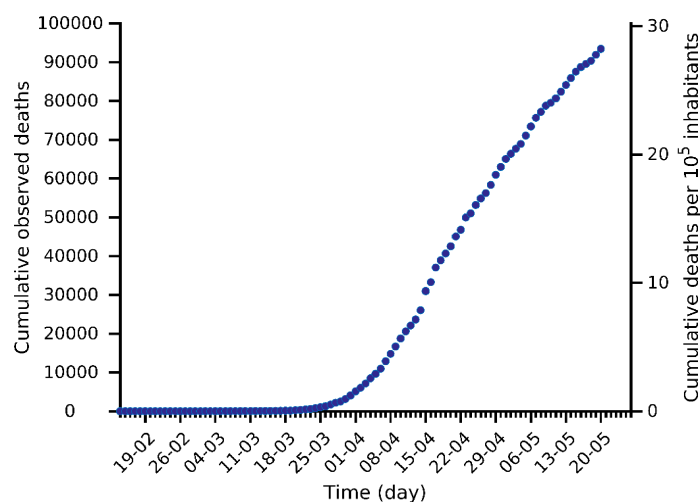
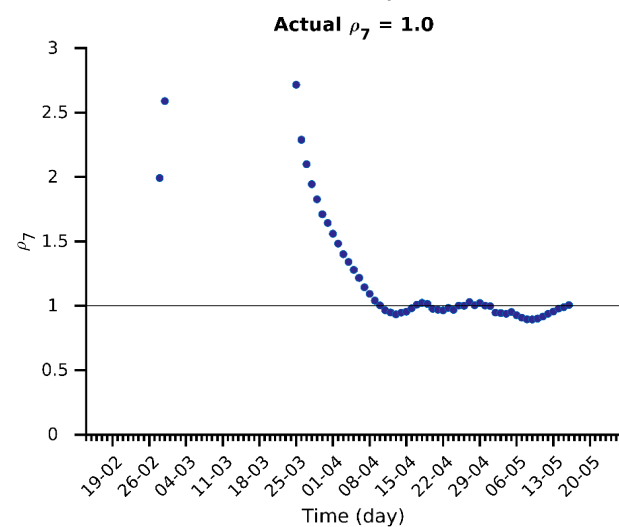
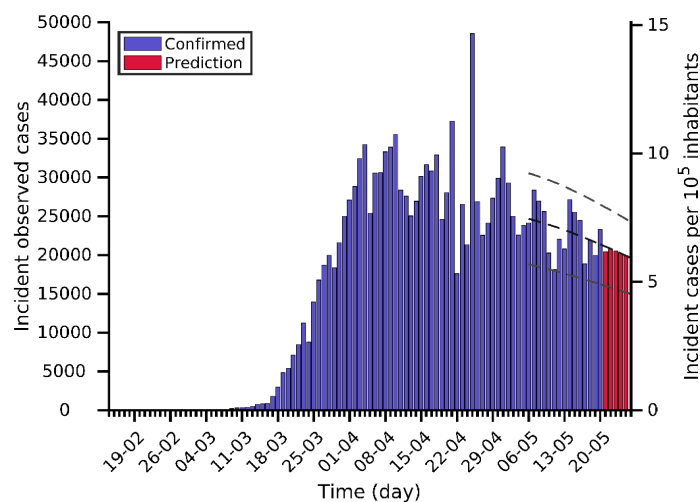
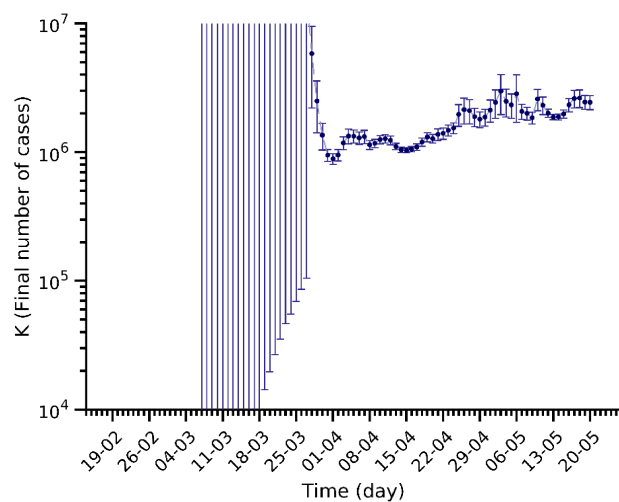
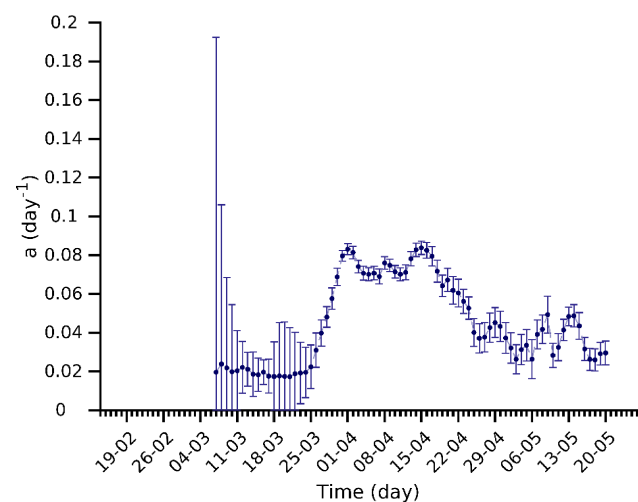
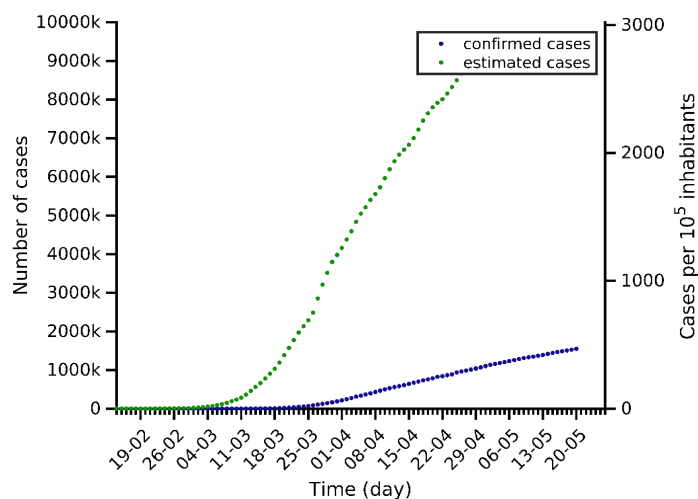
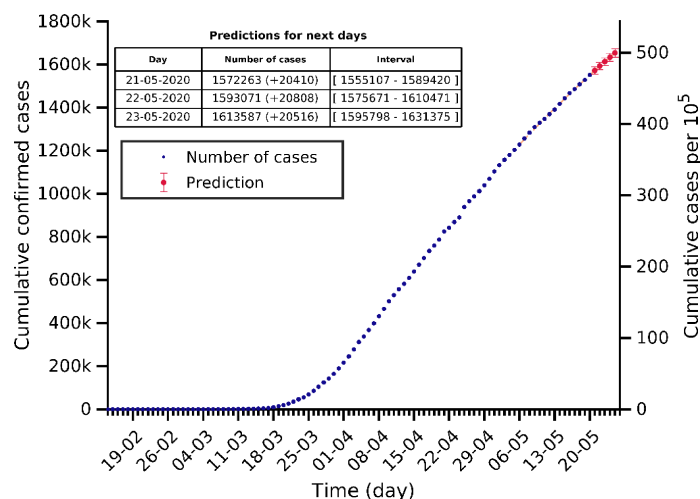
# Malta 20-05-2020. Population: 0.4M. Current cumulated incidence: 132/10<sup>5</sup>



## **(2) Analysis and prediction of COVID-19 for other countries**

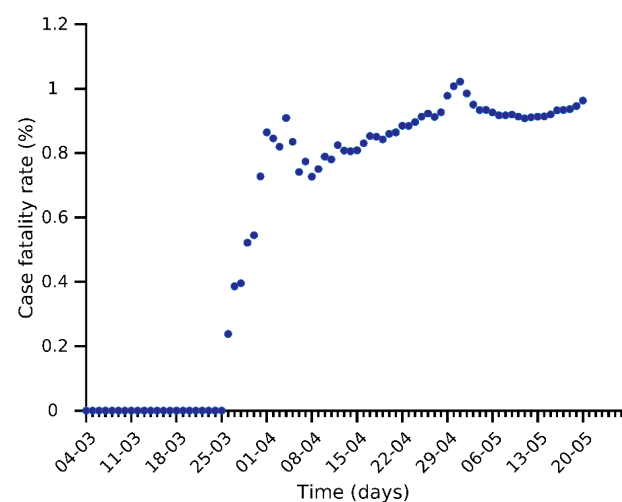
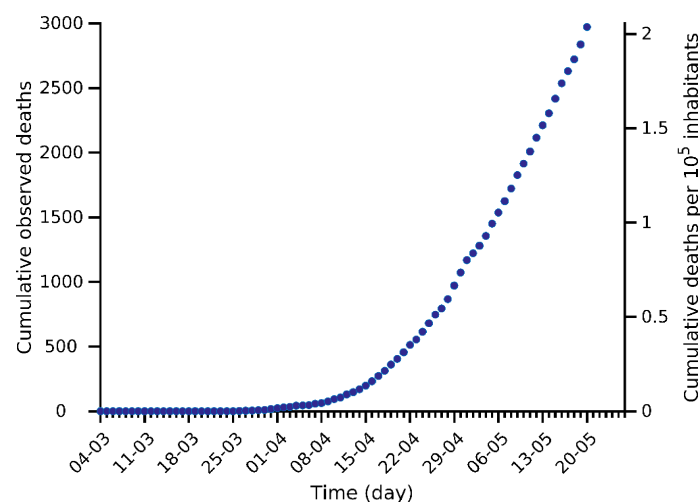
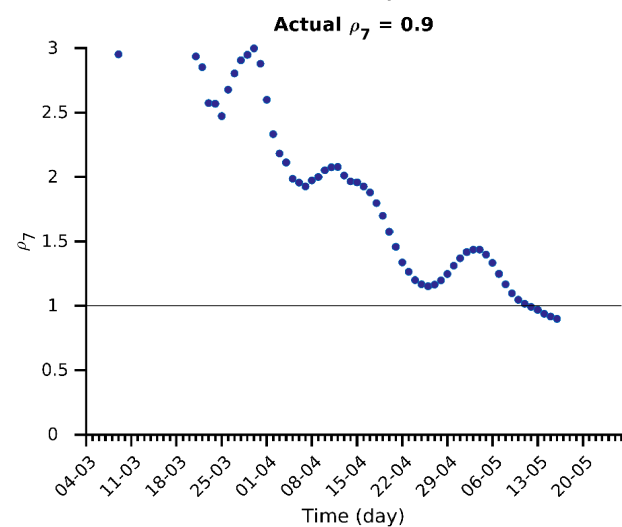
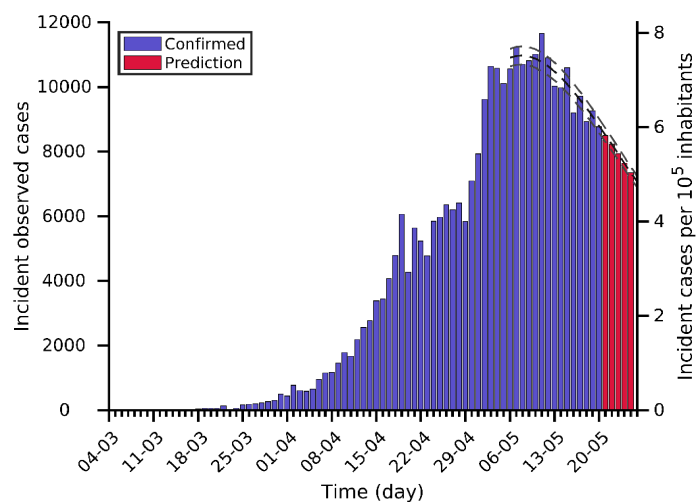
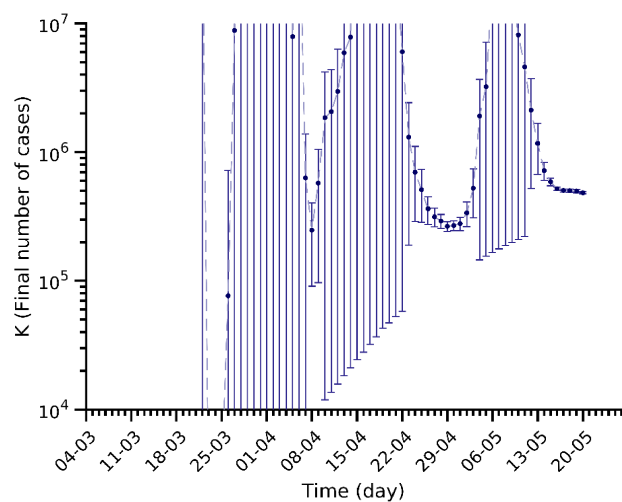
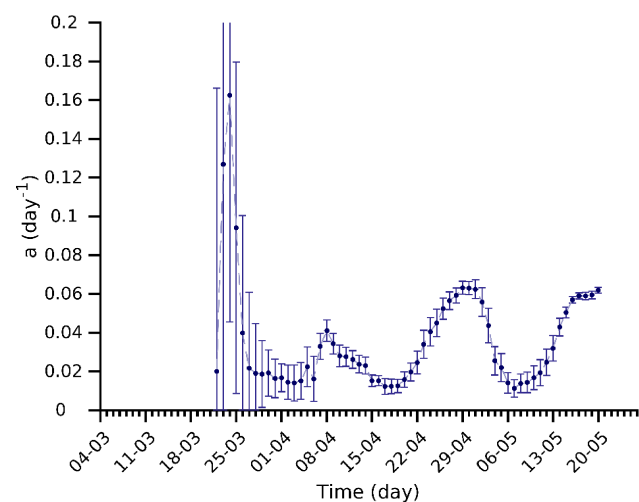
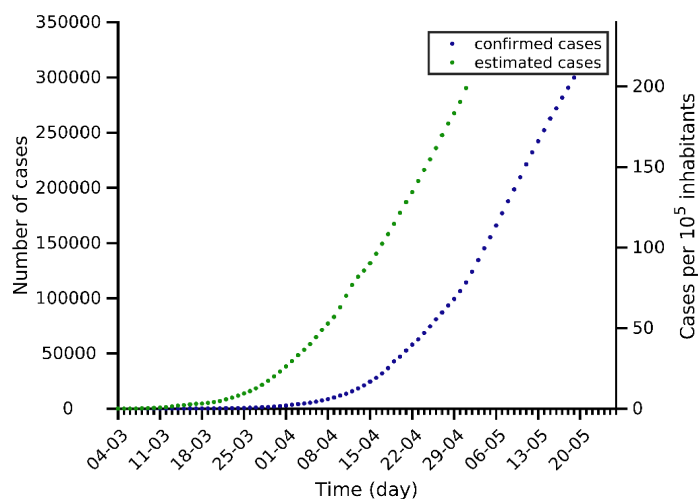
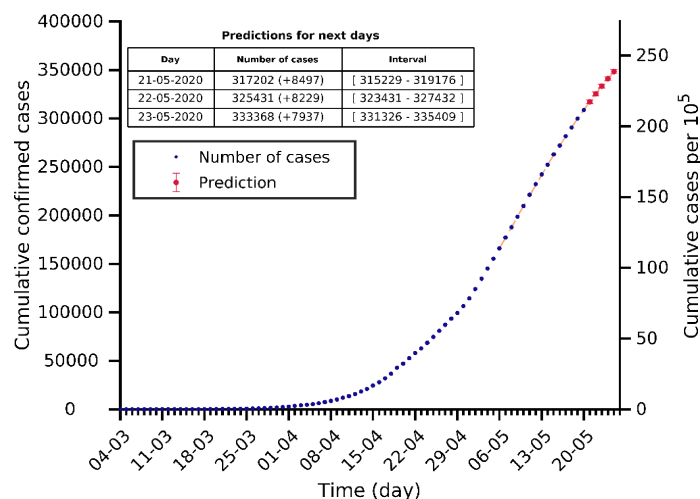
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

# USA 20-05-2020. Population: 331.0M. Current cumulated incidence: 469/10<sup>5</sup>

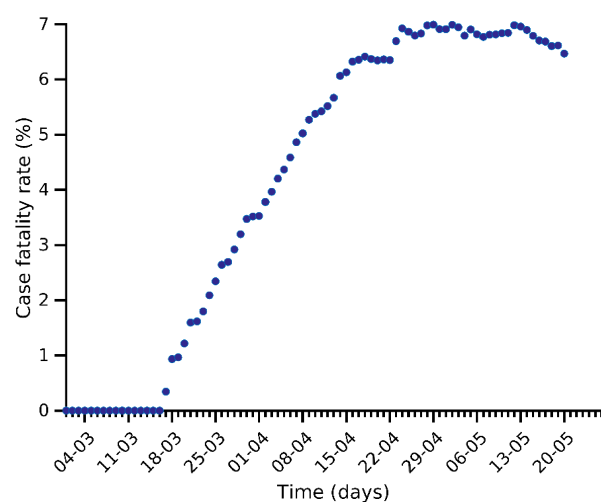
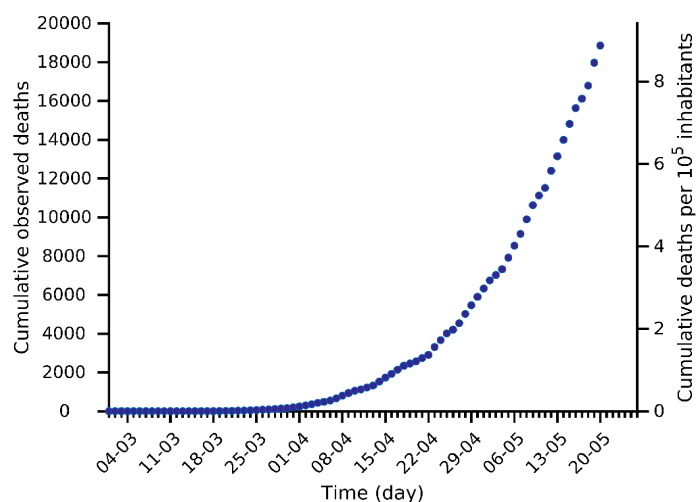
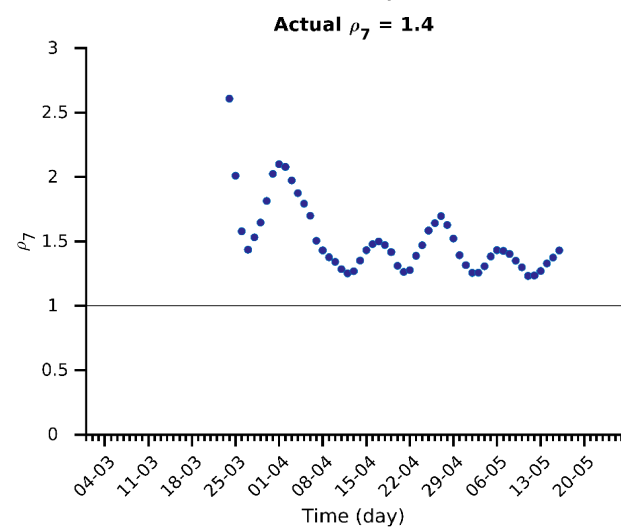
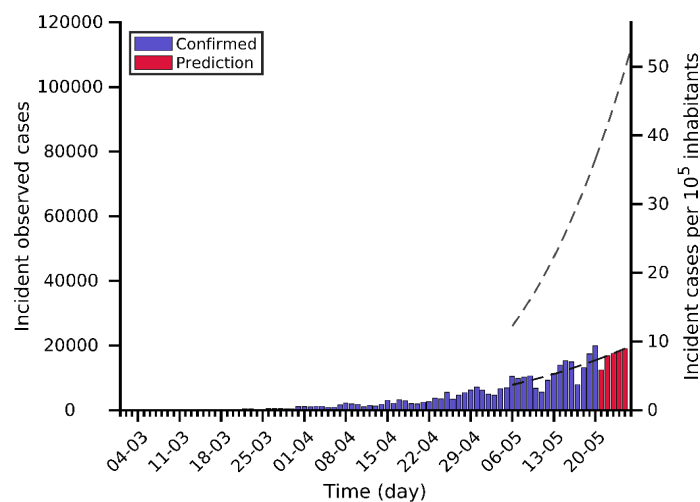
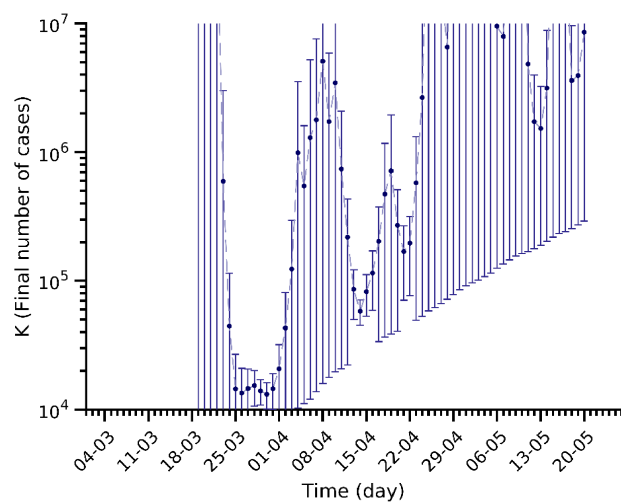
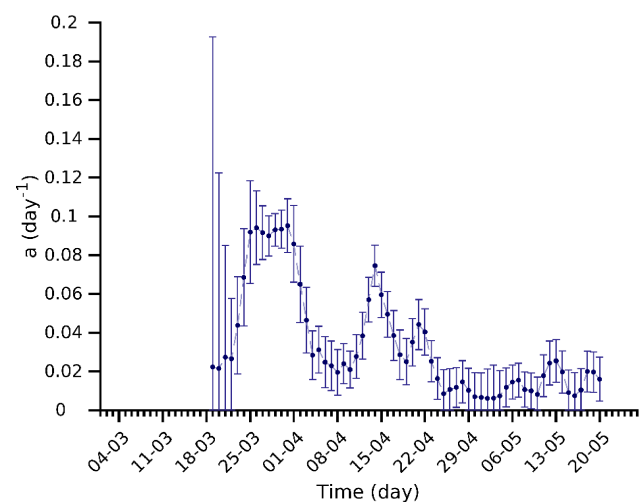
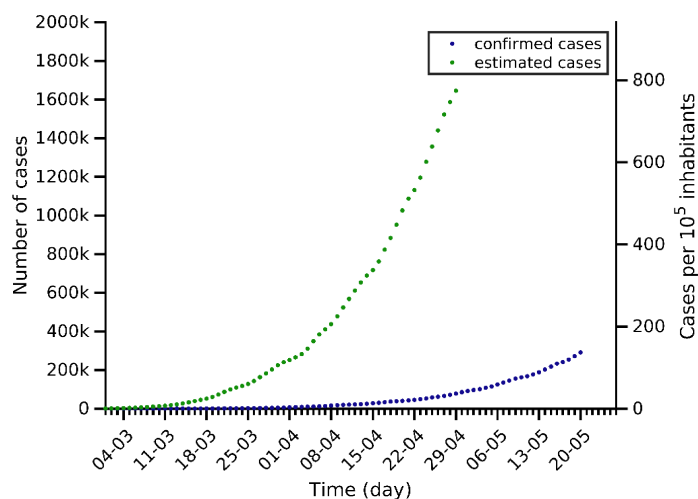
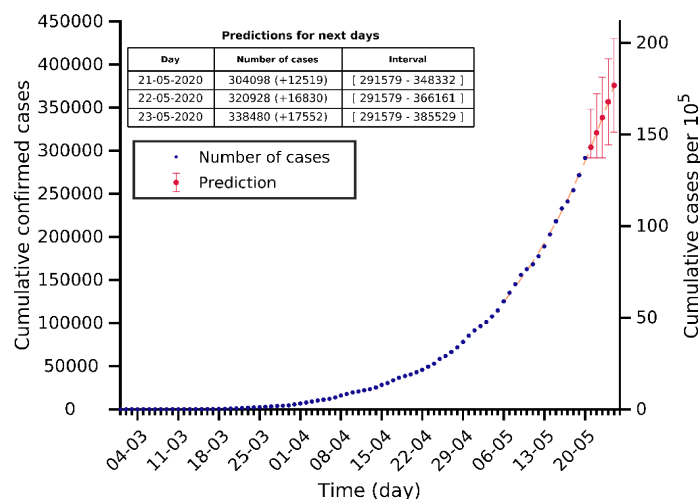




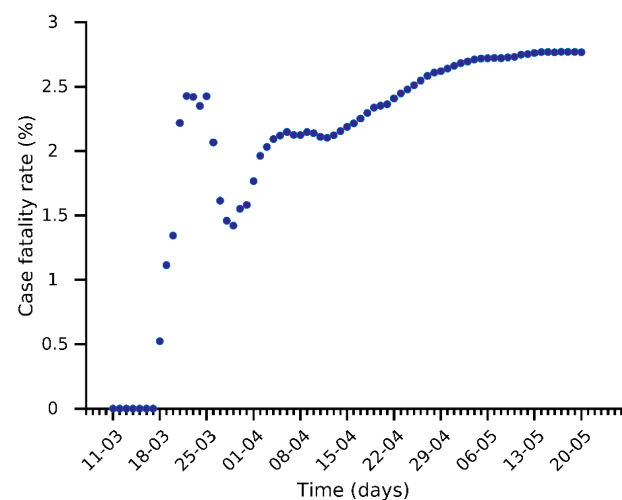
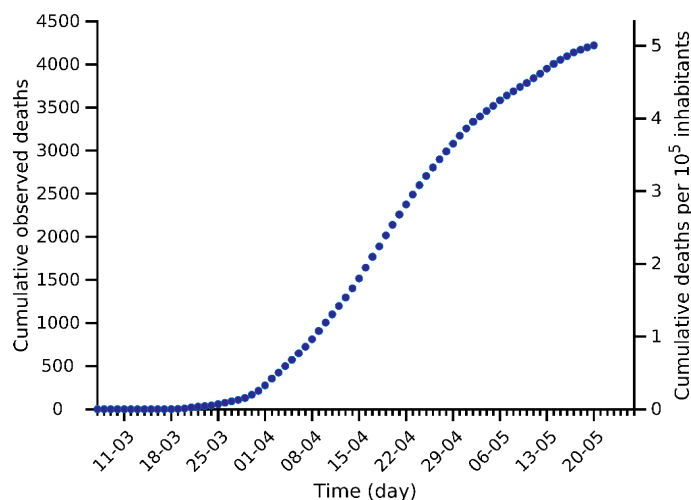
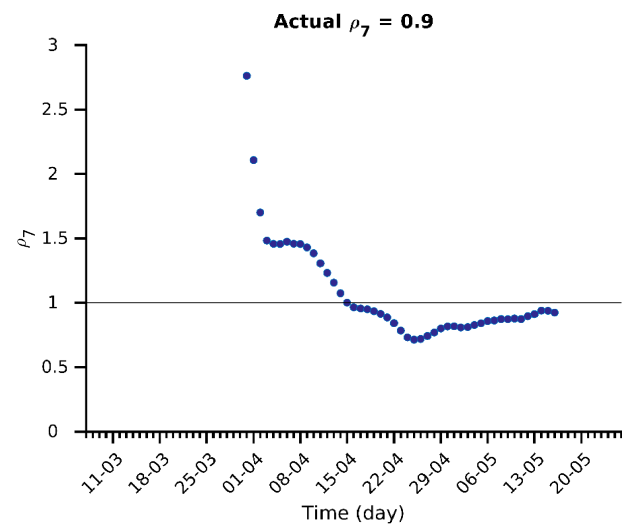
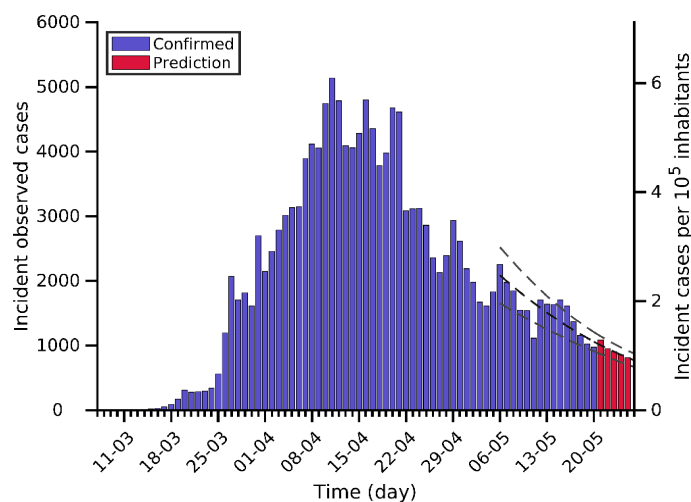
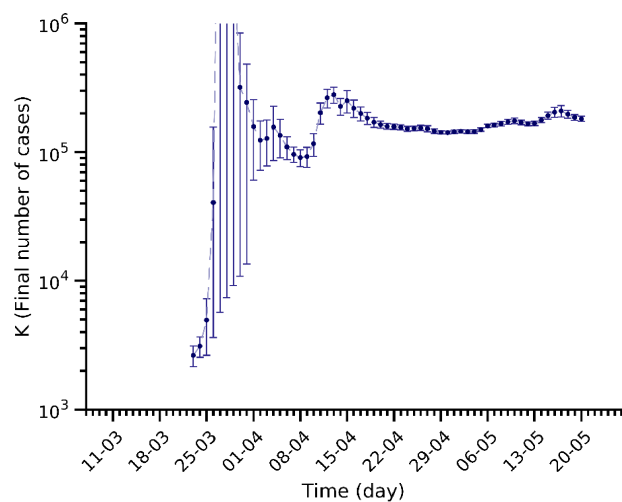
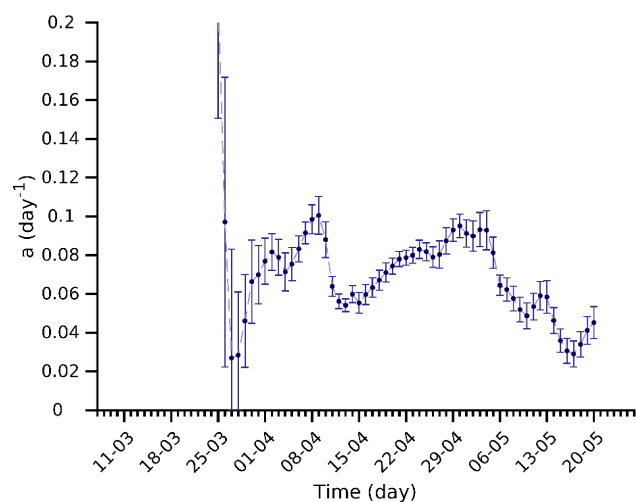
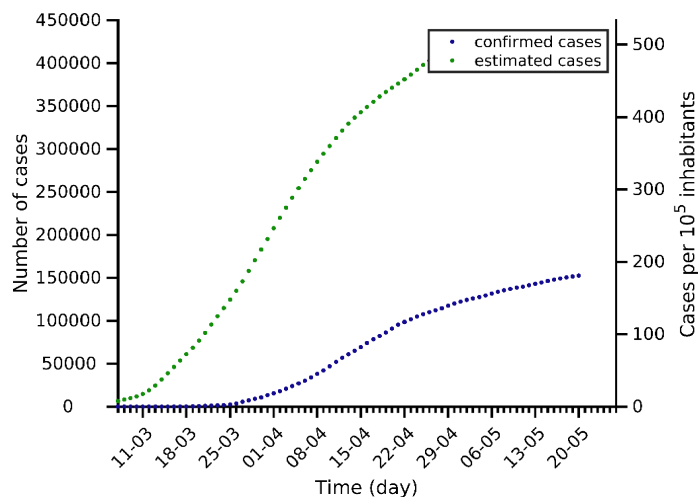
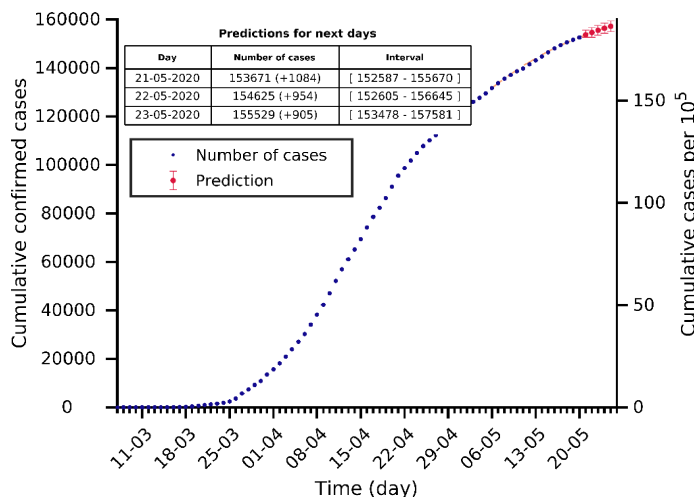
# Russia 20-05-2020. Population: 145.9M. Current cumulated incidence: 212/10<sup>5</sup>



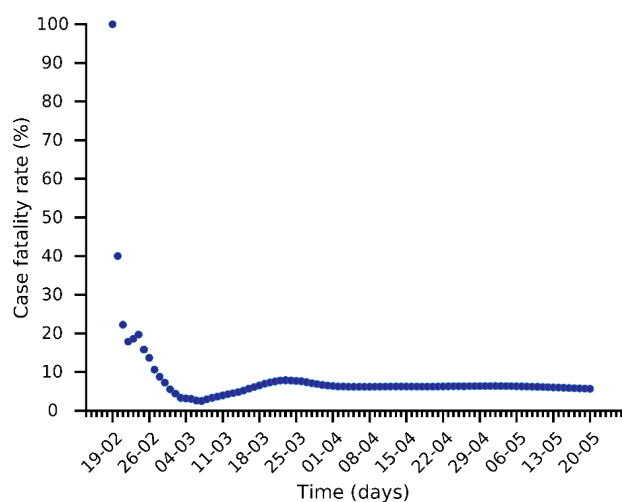
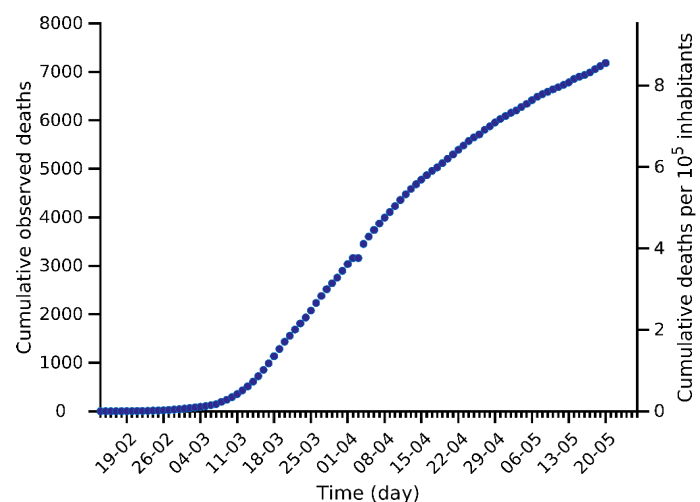
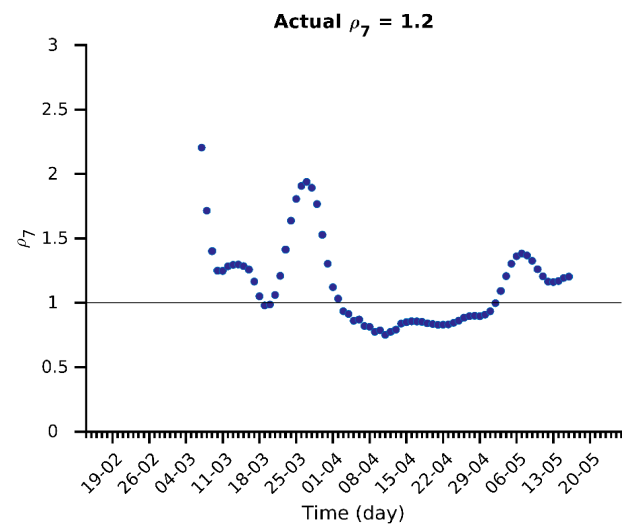
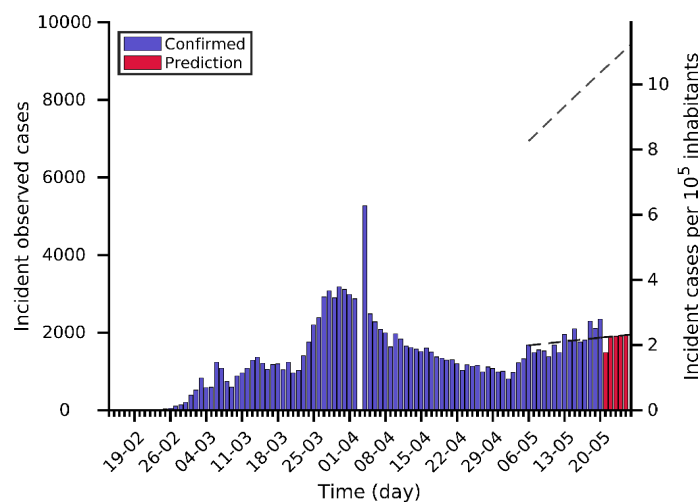
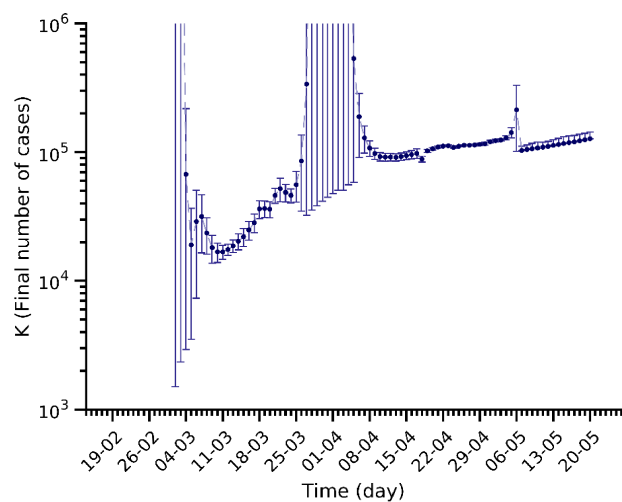
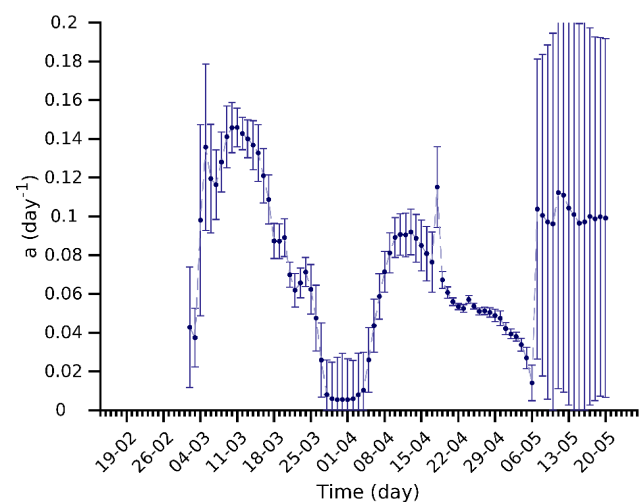
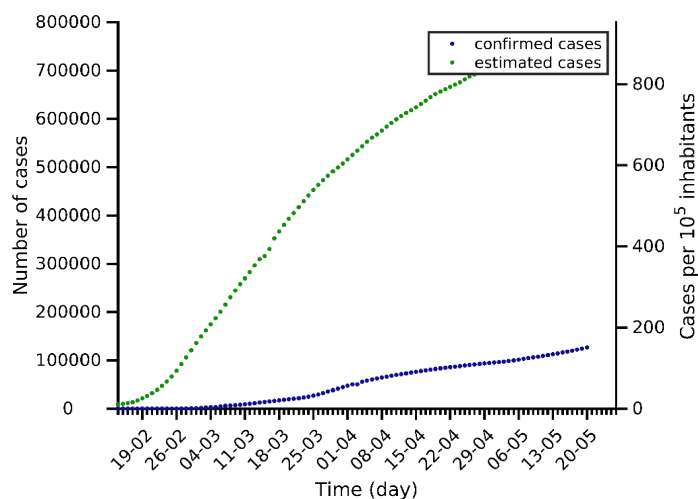
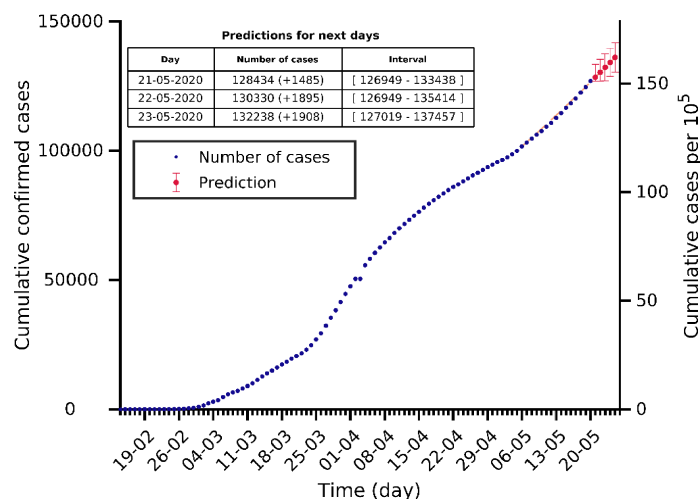
# Brazil 20-05-2020. Population: 212.6M. Current cumulated incidence: 137/10<sup>5</sup>



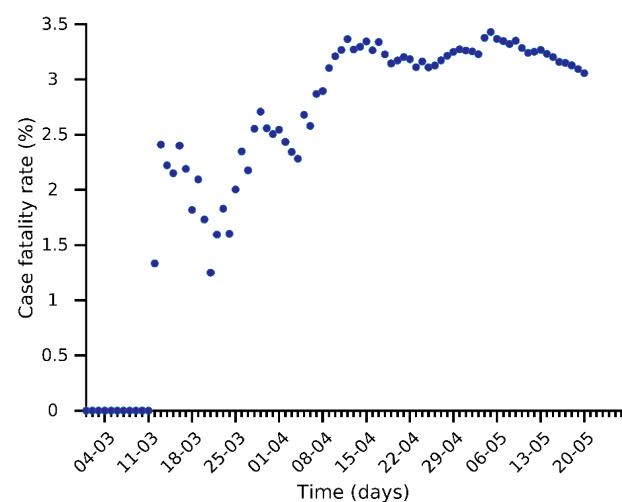
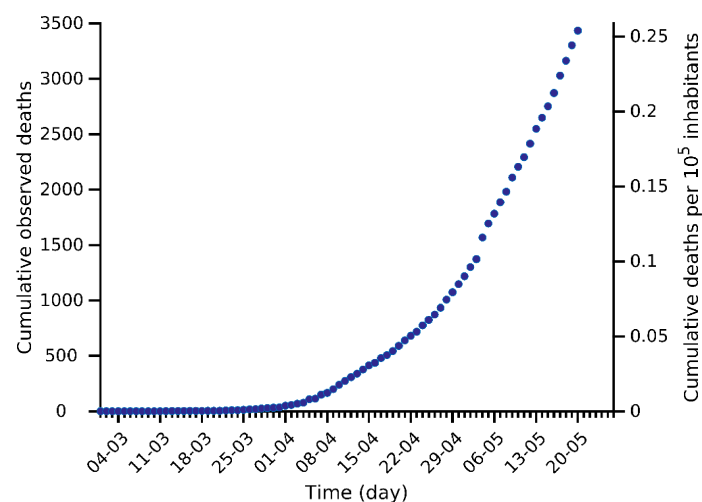
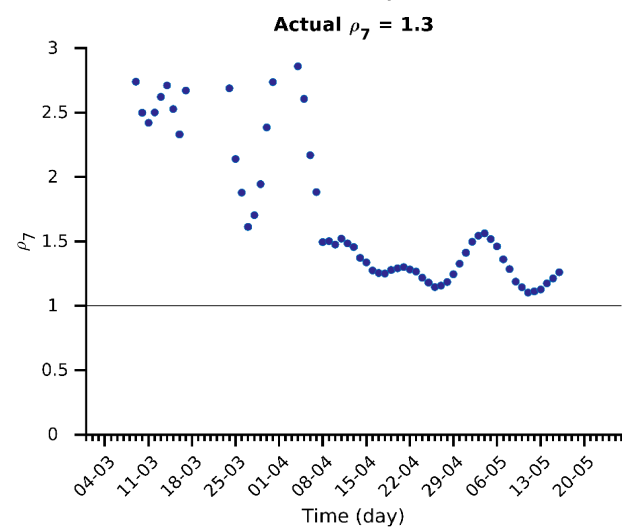
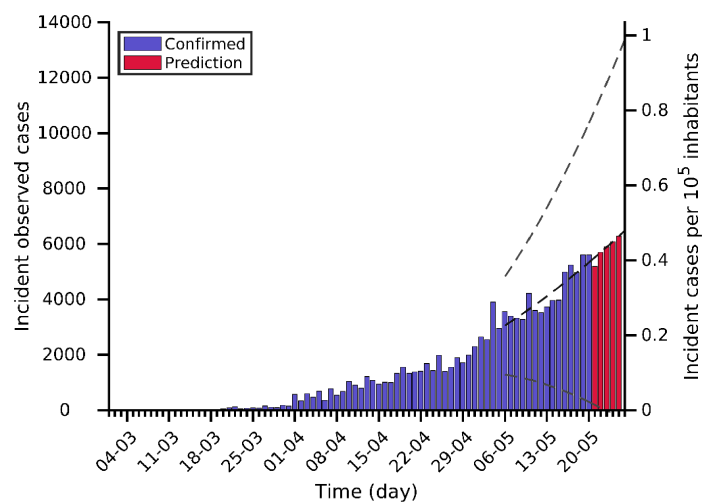
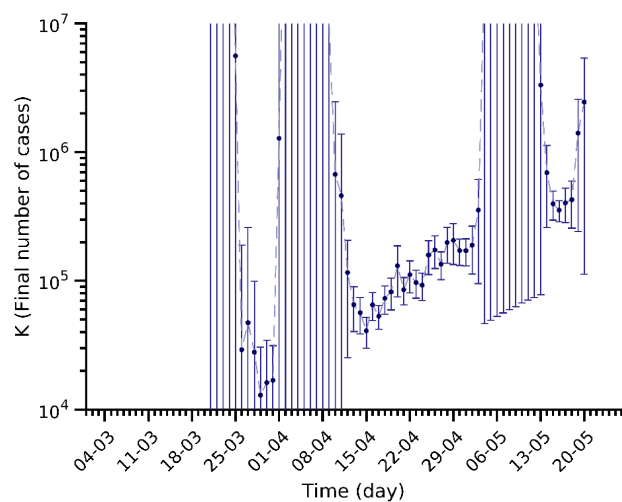
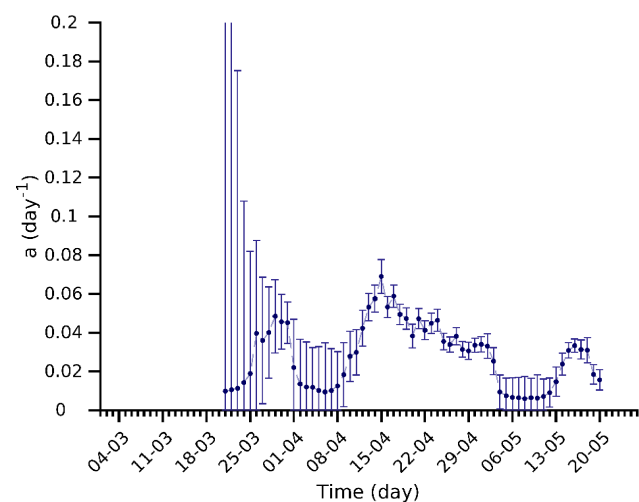
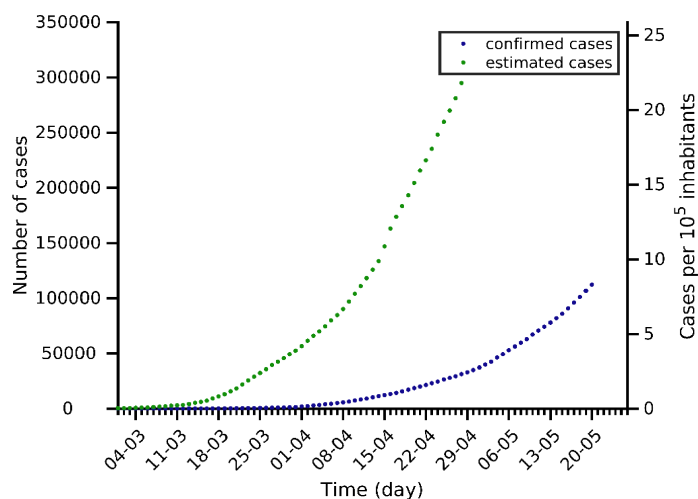
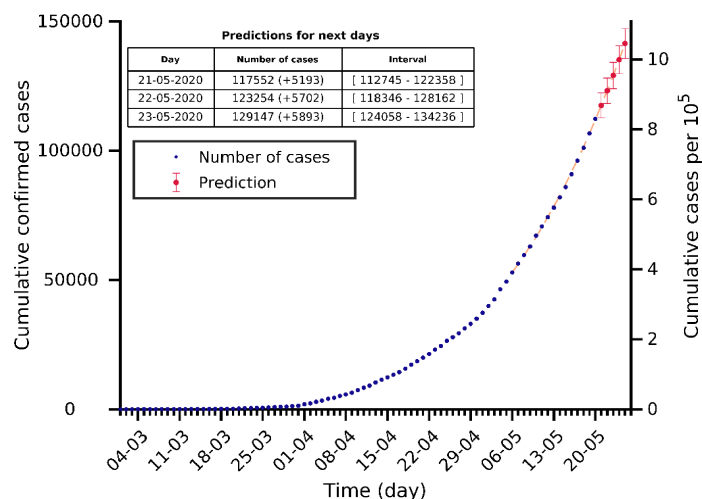
# Turkey 20-05-2020. Population: 84.3M. Current cumulated incidence: 181/10<sup>5</sup>



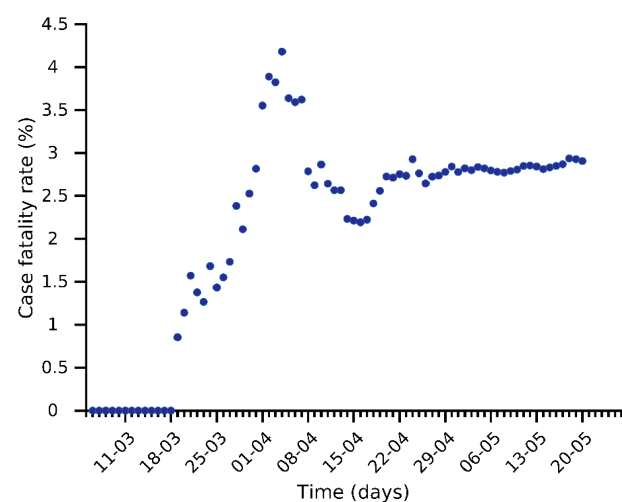
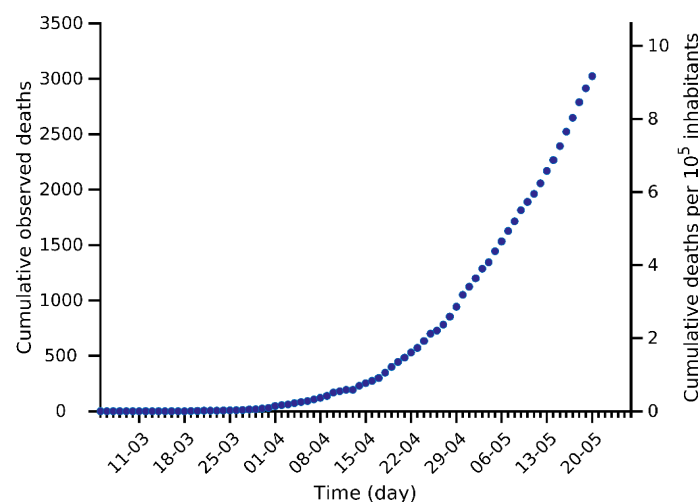
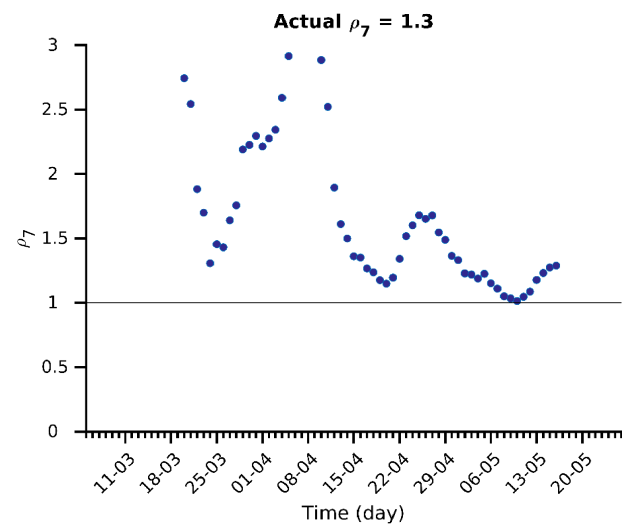
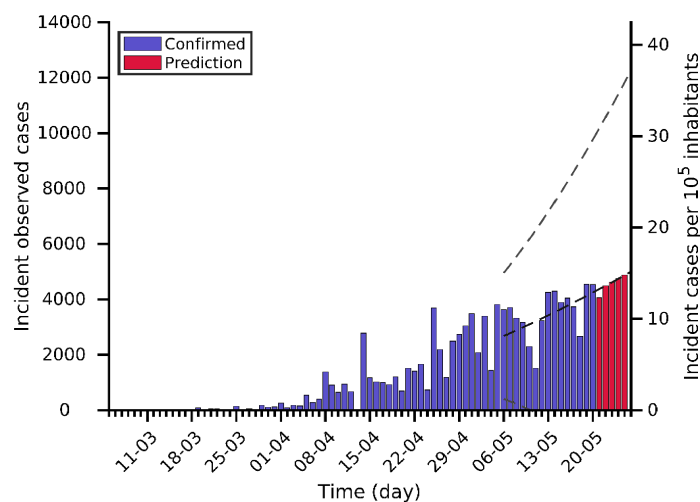
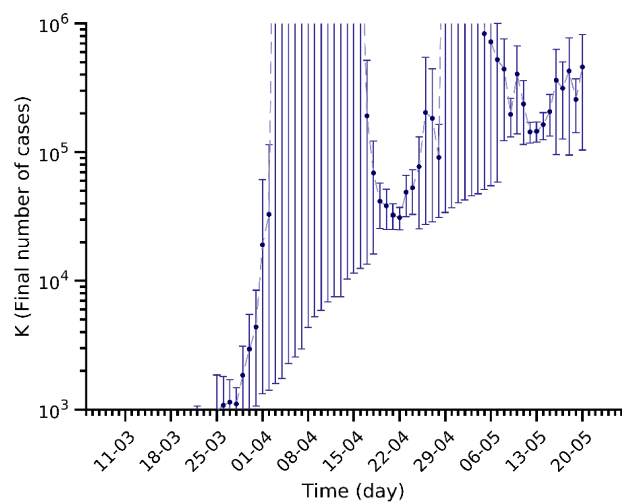
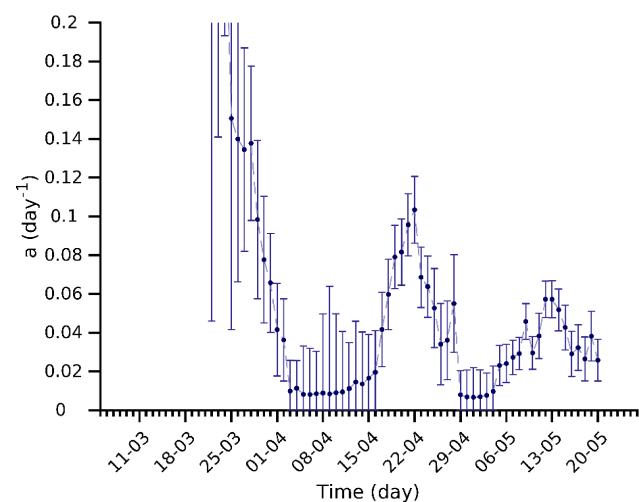
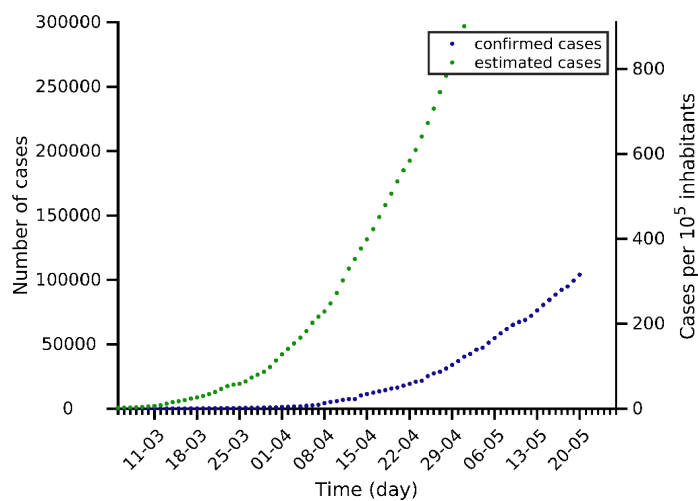
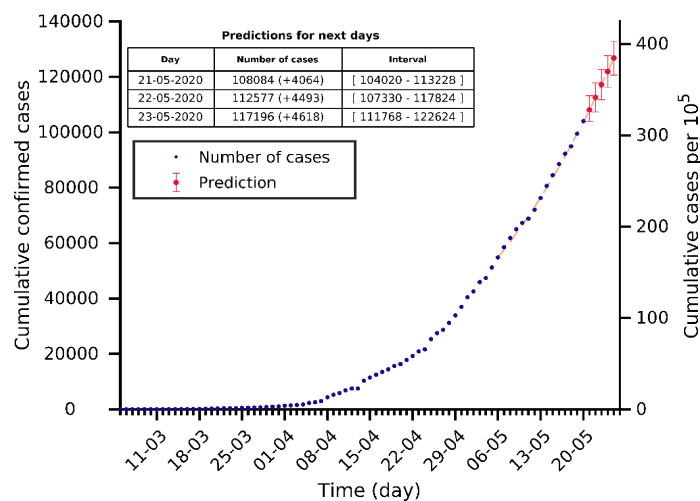
# Iran 20-05-2020. Population: 84.0M. Current cumulated incidence: 151/10<sup>5</sup>



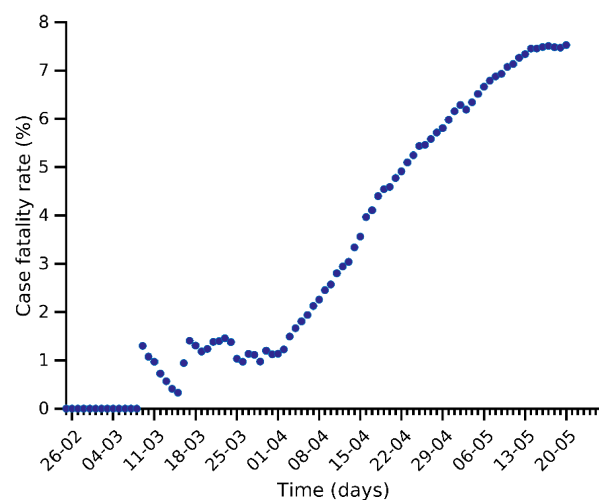
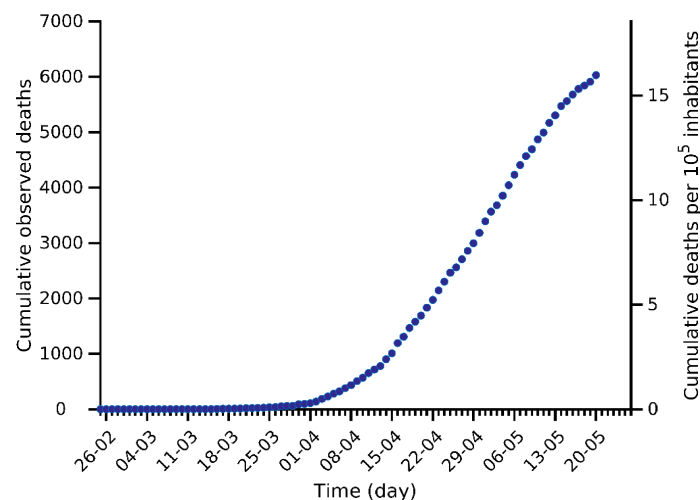
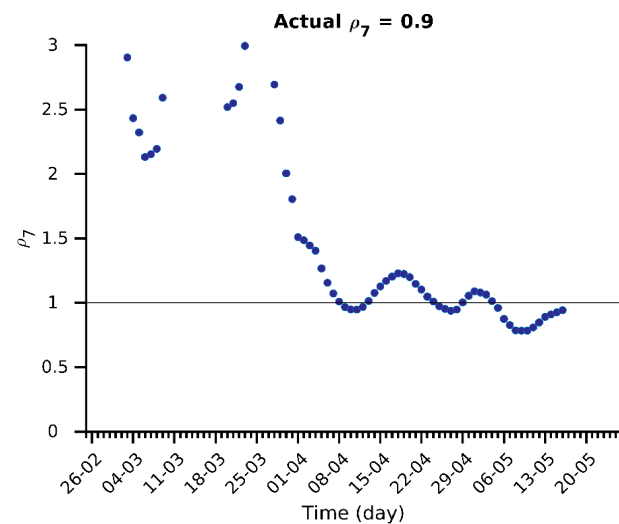
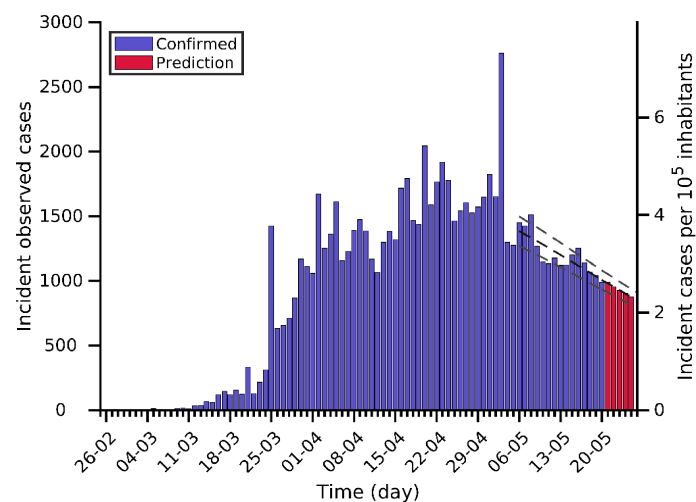
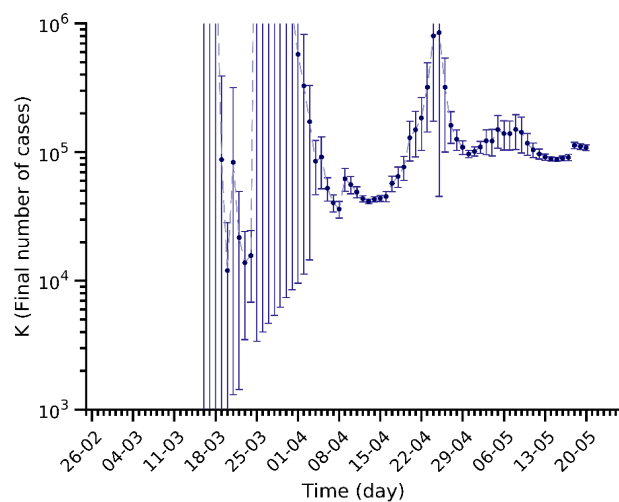
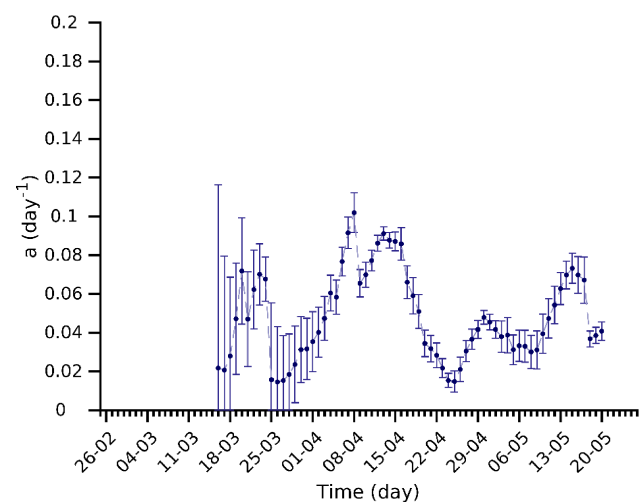
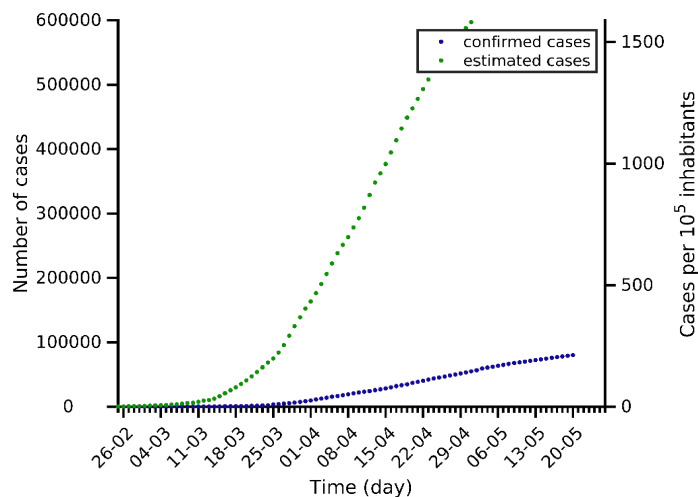
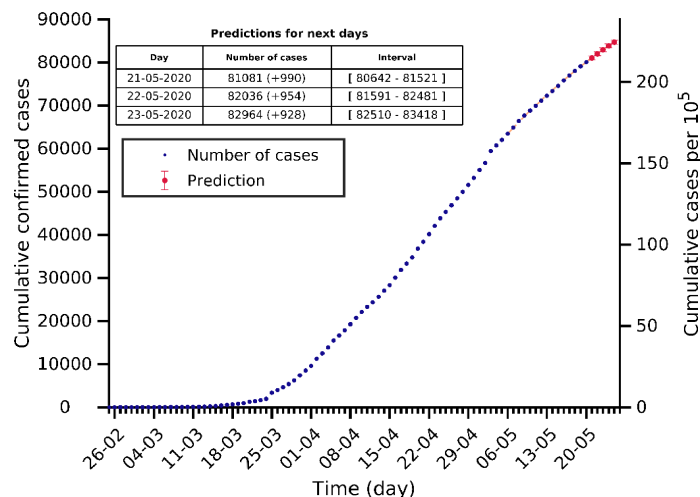
# India 20-05-2020. Population: 1353.0M. Current cumulated incidence: 8/10<sup>5</sup>



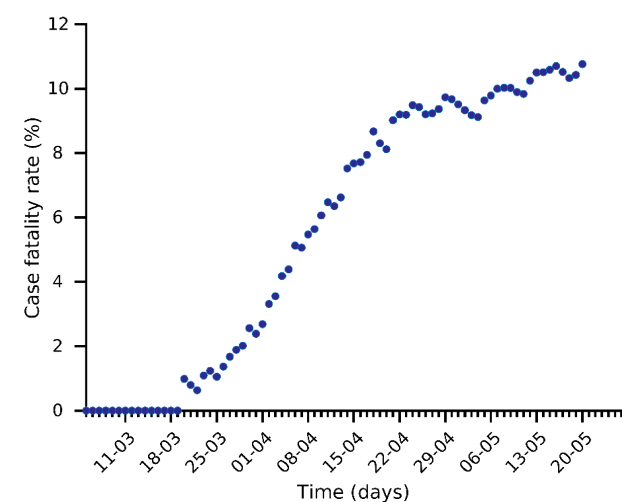
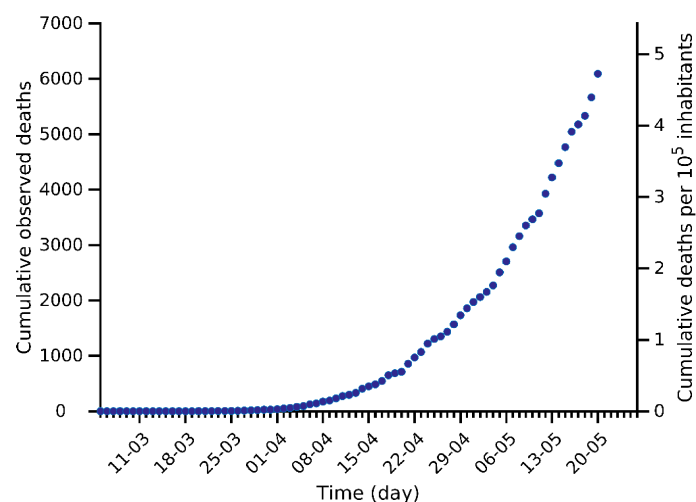
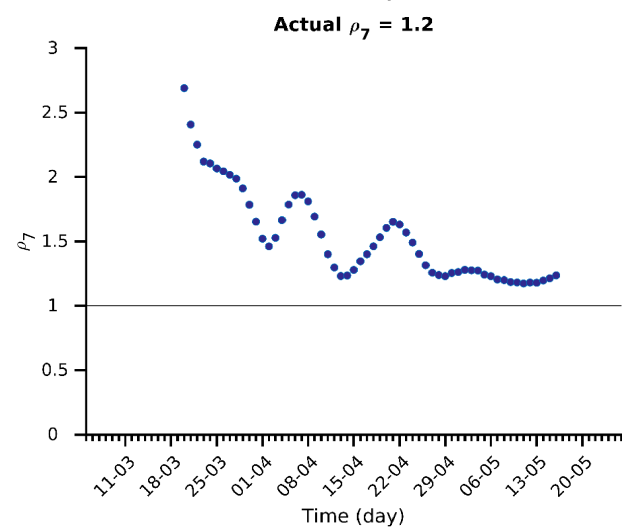
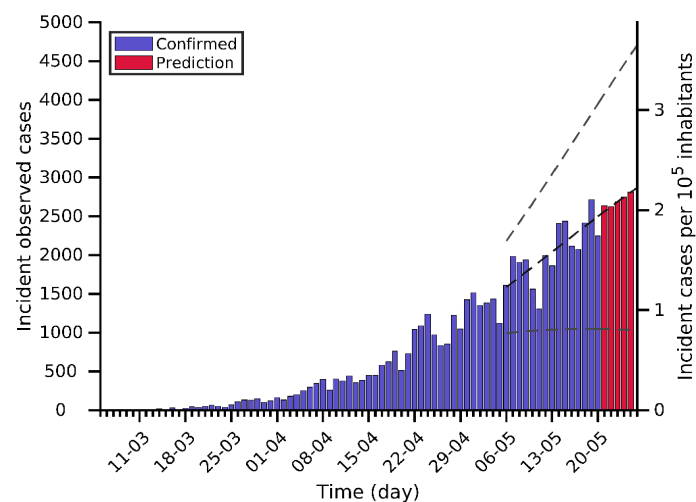
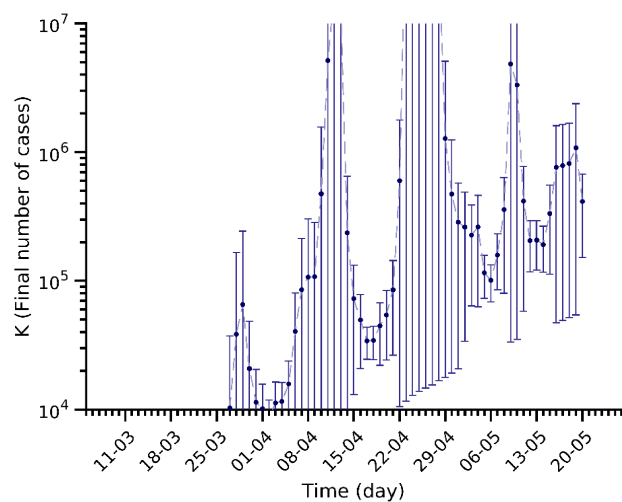
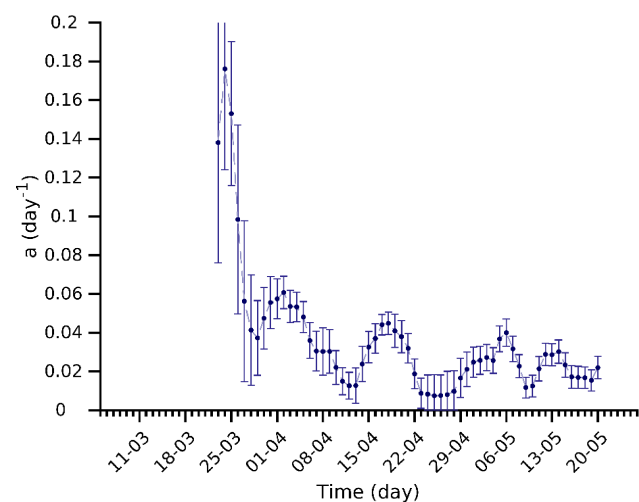
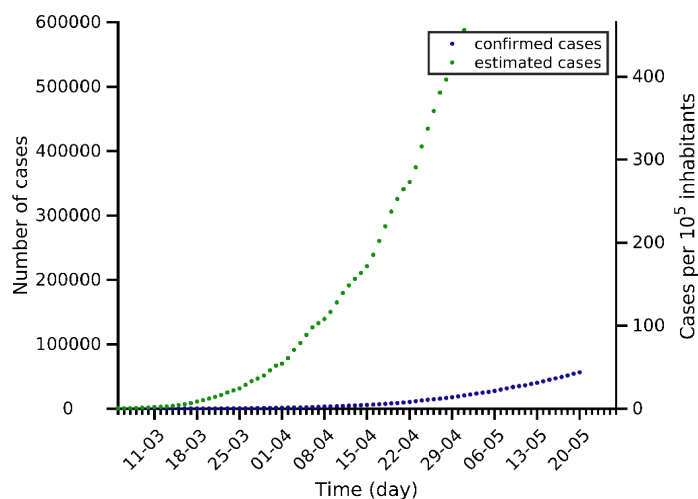
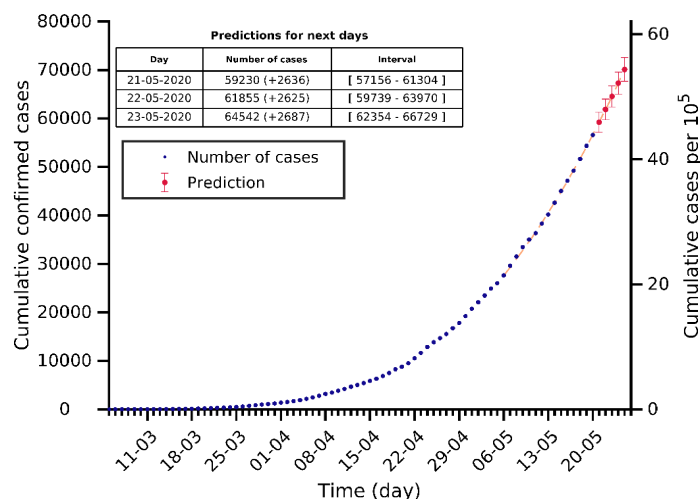
# Peru 20-05-2020. Population: 33.0M. Current cumulated incidence: 315/10<sup>5</sup>



# Canada 20-05-2020. Population: 37.7M. Current cumulated incidence: 212/10<sup>5</sup>

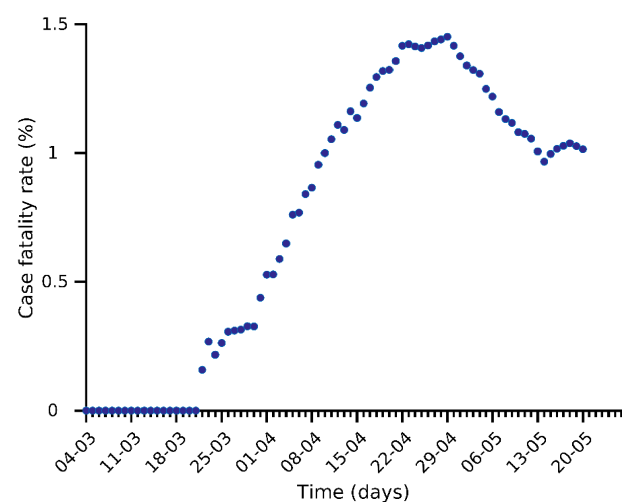
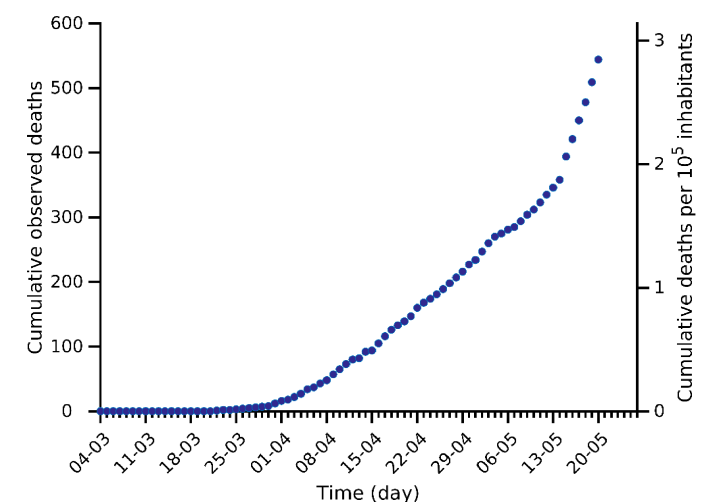
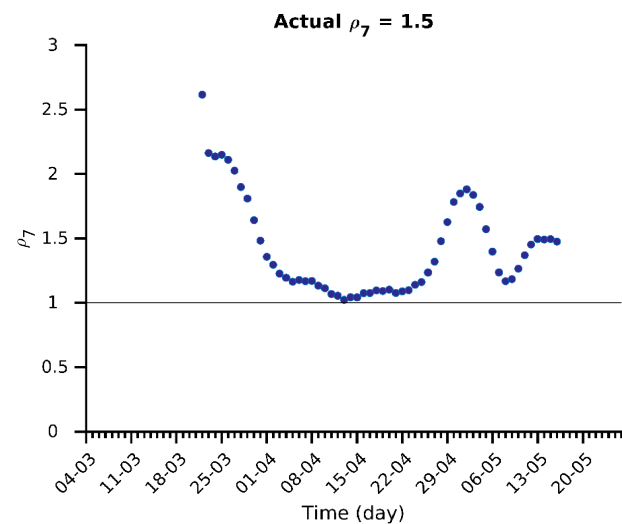
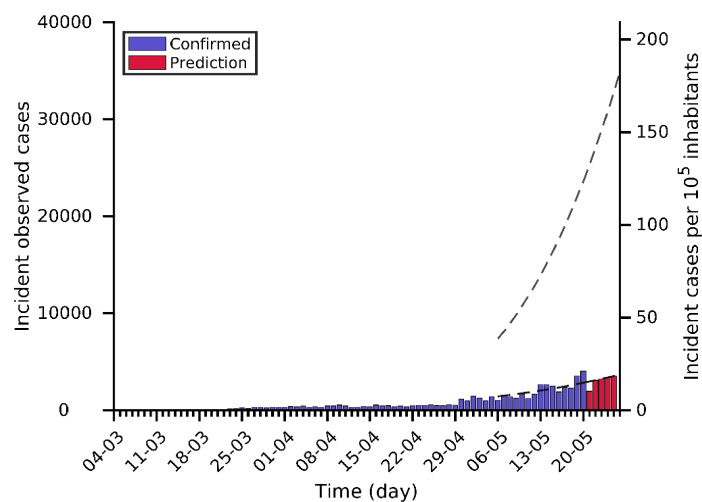
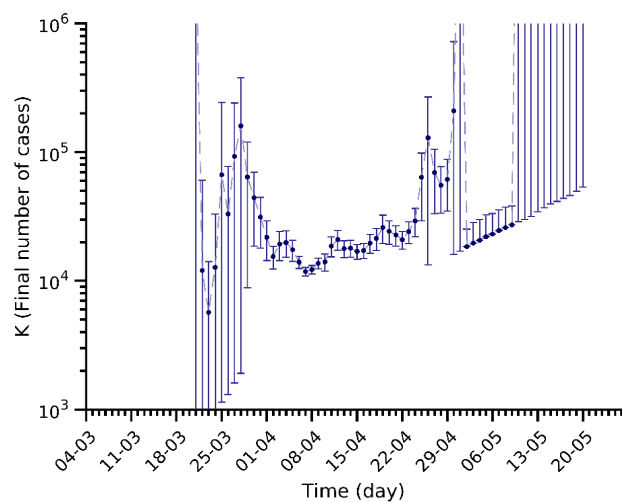
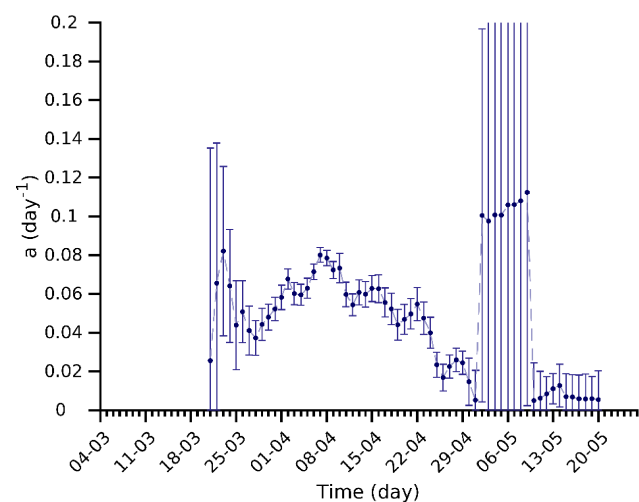
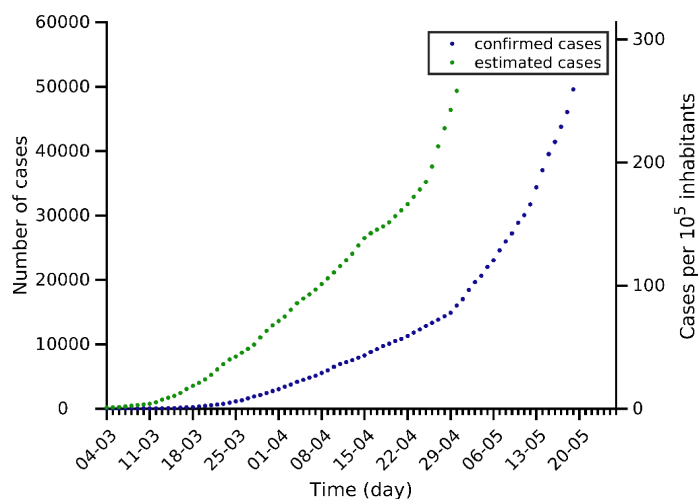
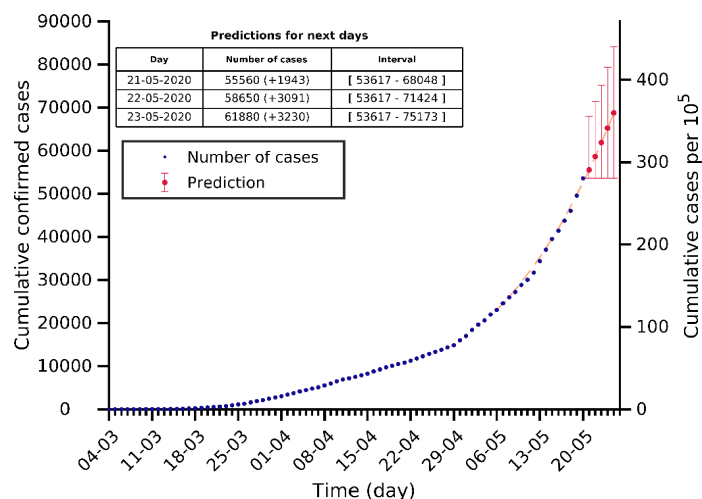


# Mexico 20-05-2020. Population: 128.9M. Current cumulated incidence: 44/10<sup>5</sup>

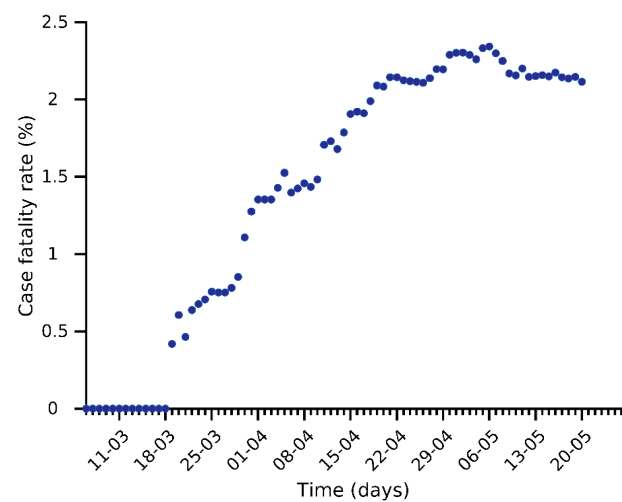
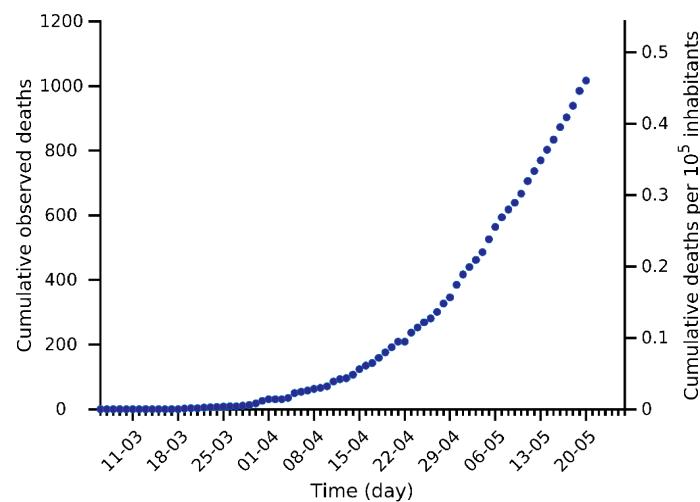
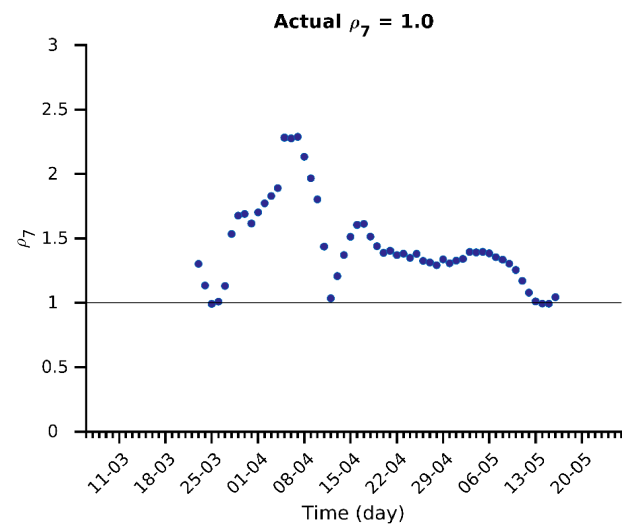
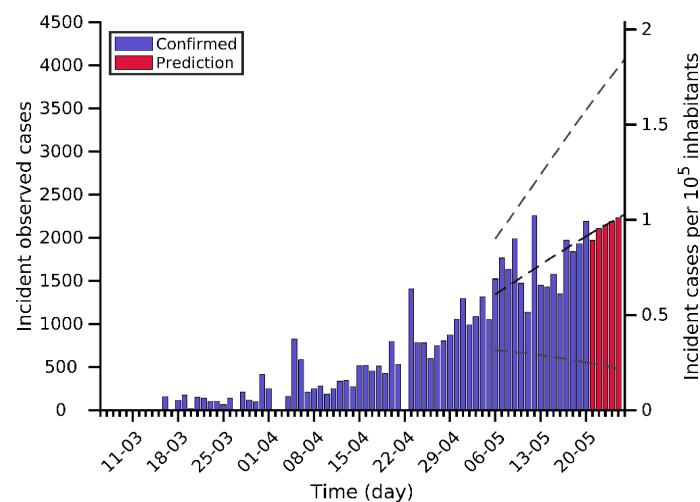
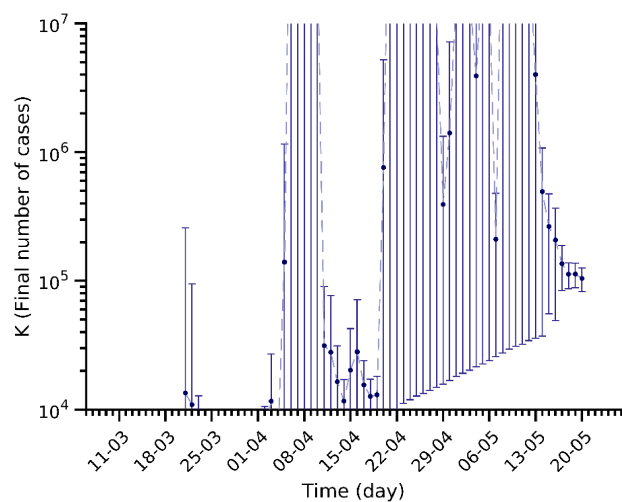
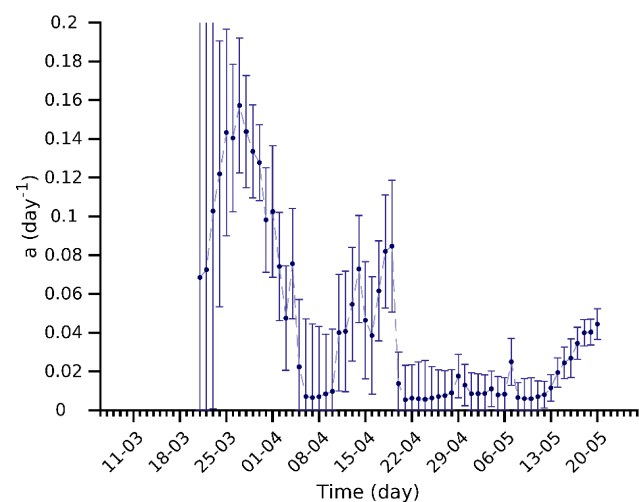
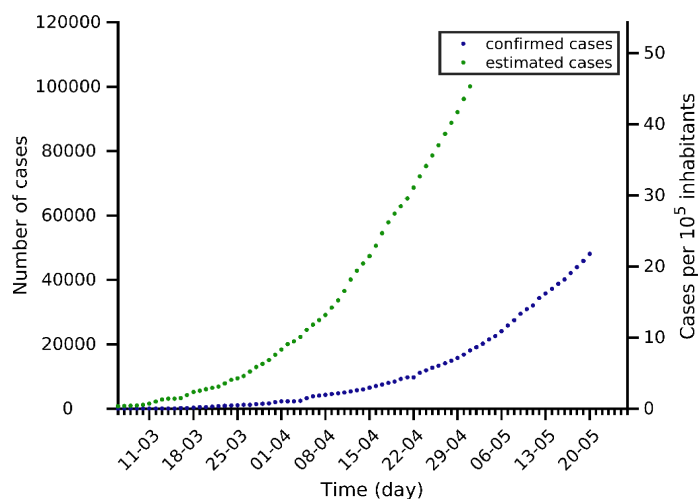
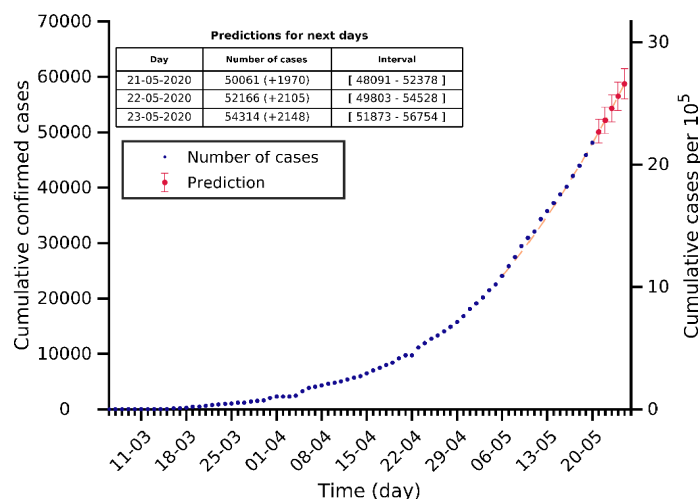




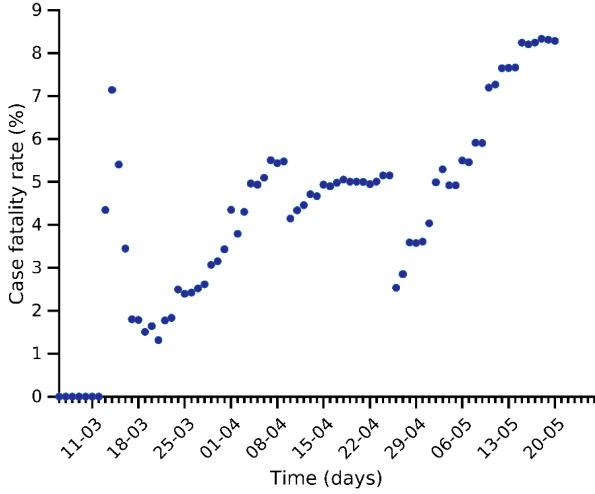
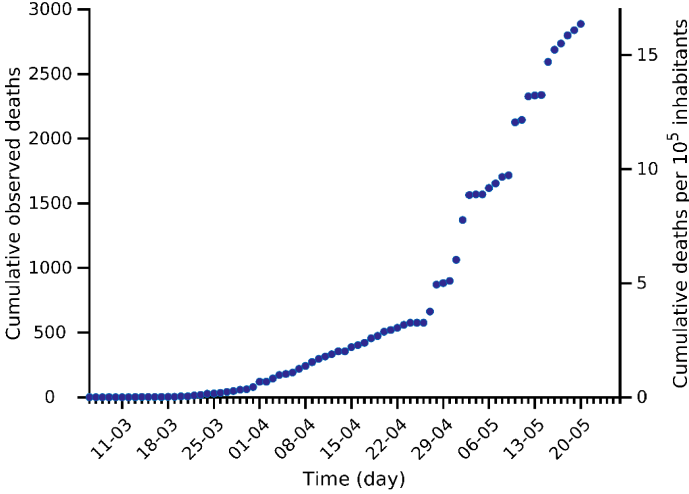
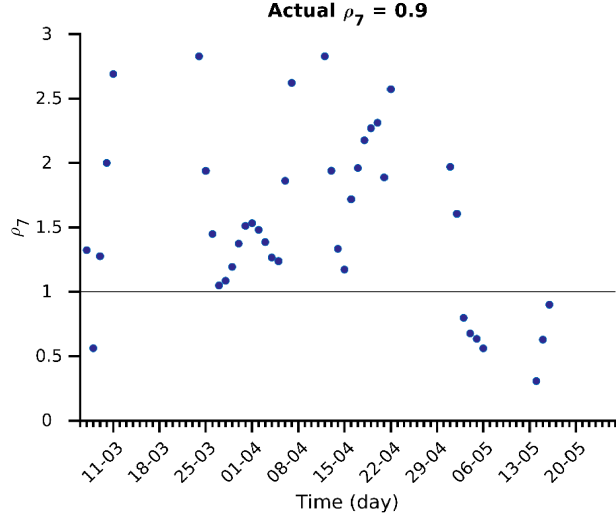
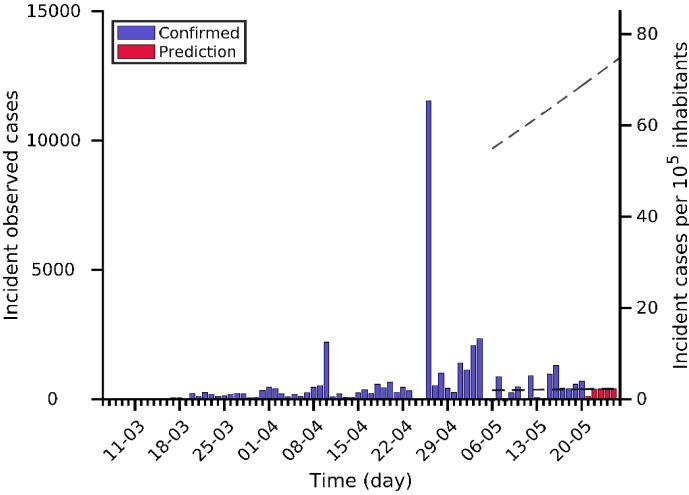
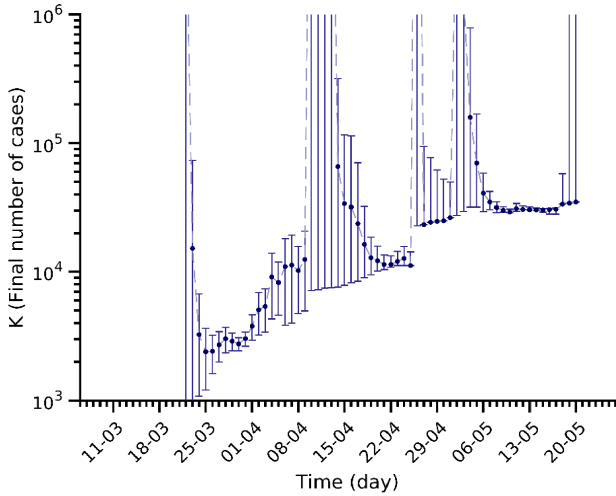
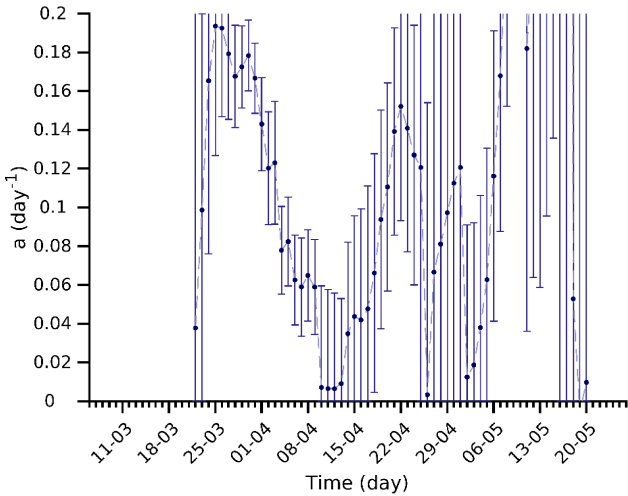
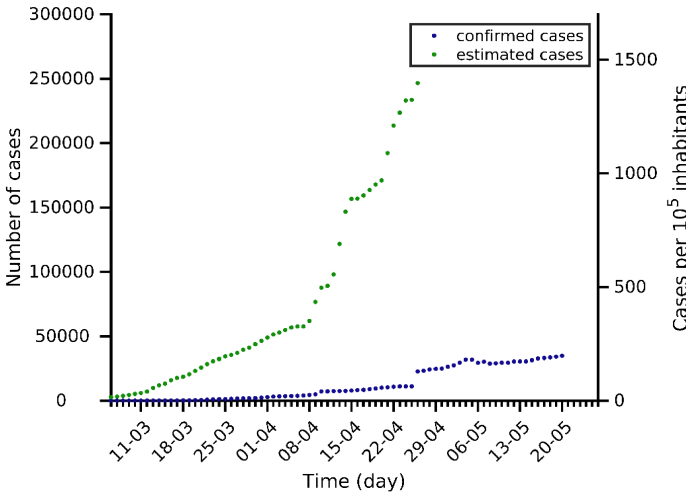
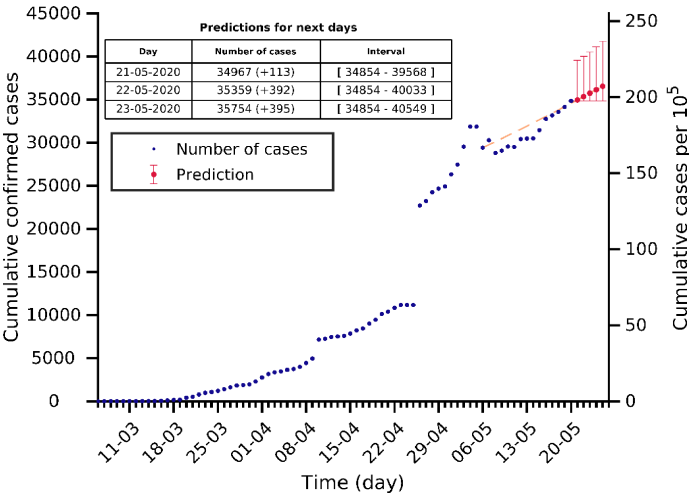
# Chile 20-05-2020. Population: 19.1M. Current cumulated incidence: 280/10<sup>5</sup>



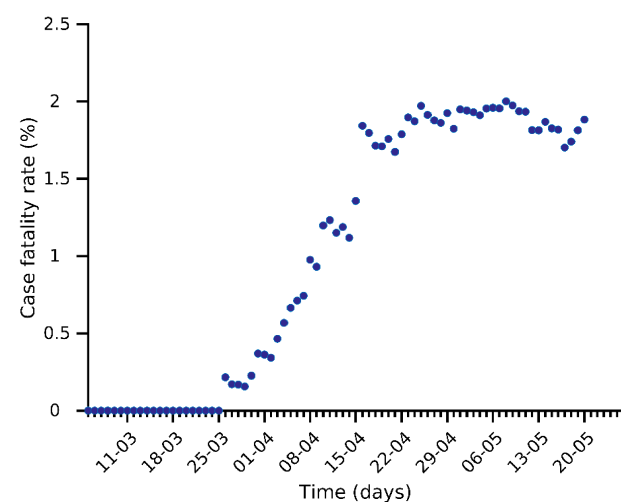
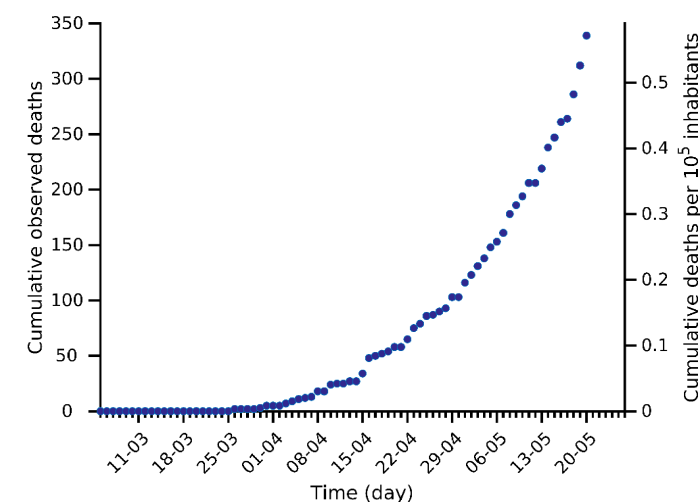
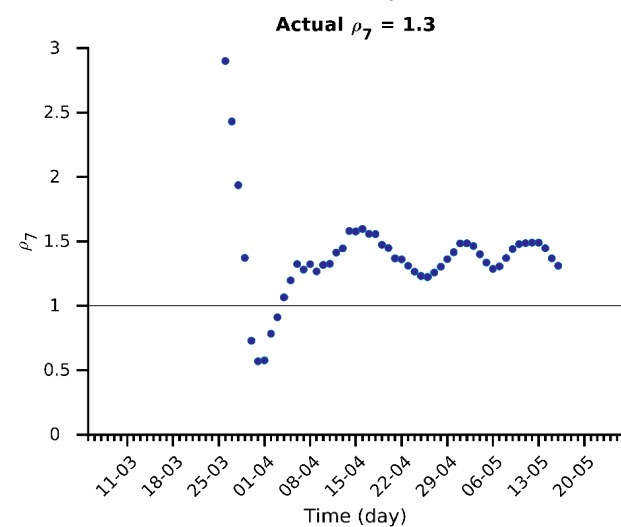
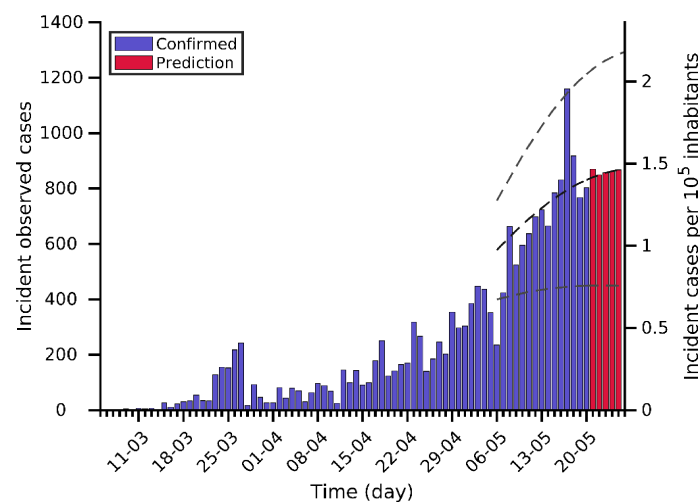
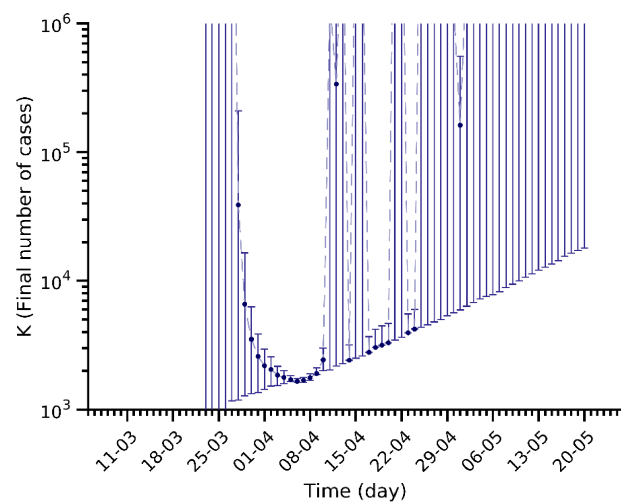
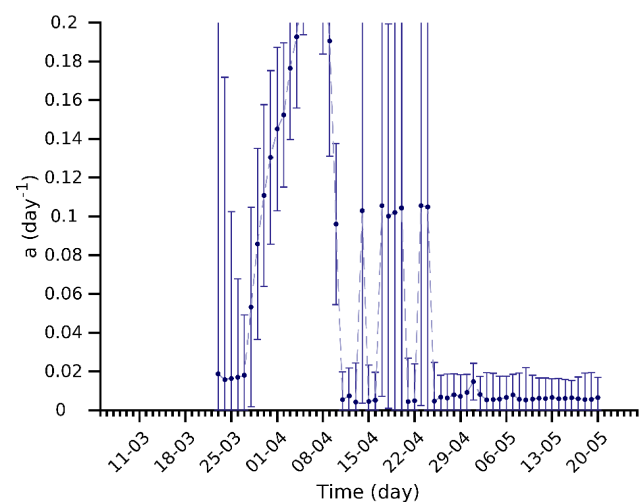
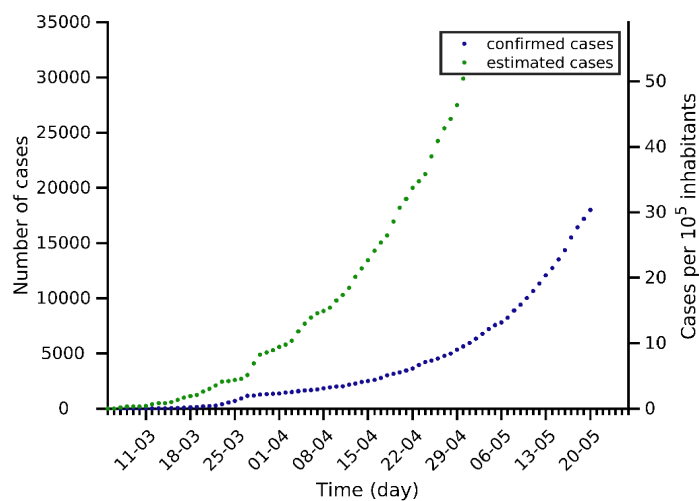
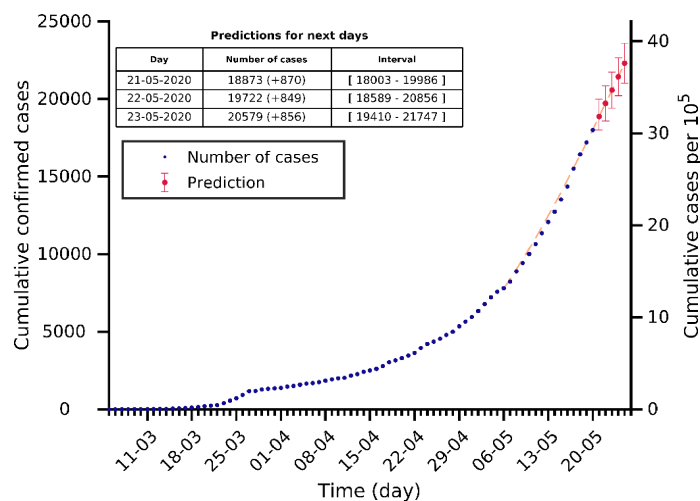
# Pakistan 20-05-2020. Population: 220.9M. Current cumulated incidence: 22/10<sup>5</sup>



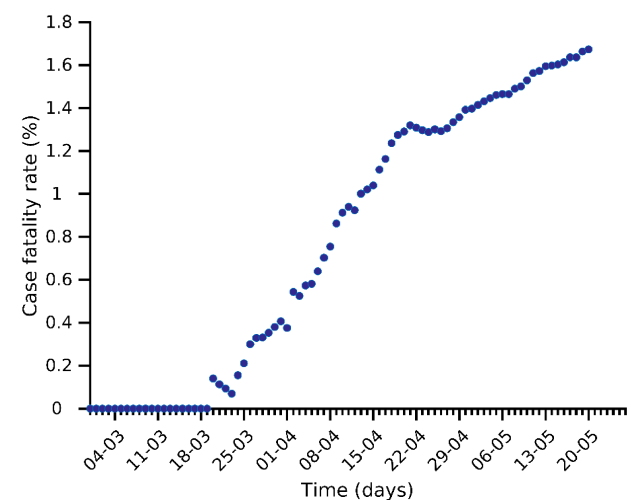
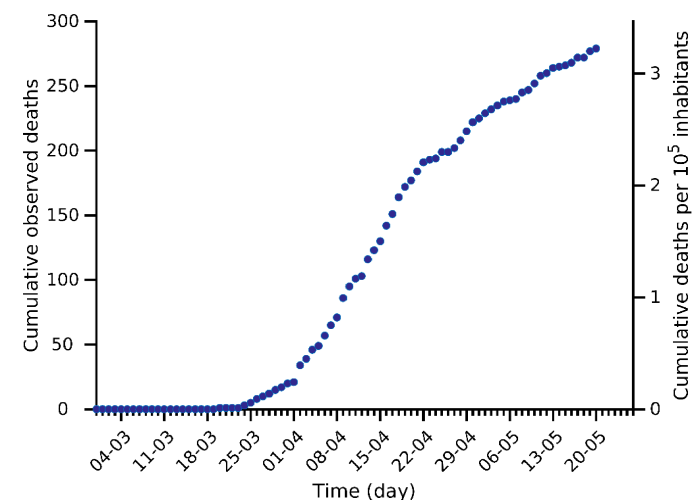
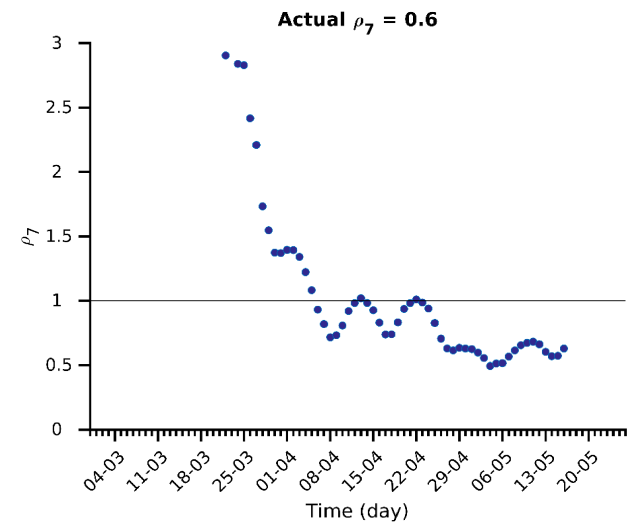
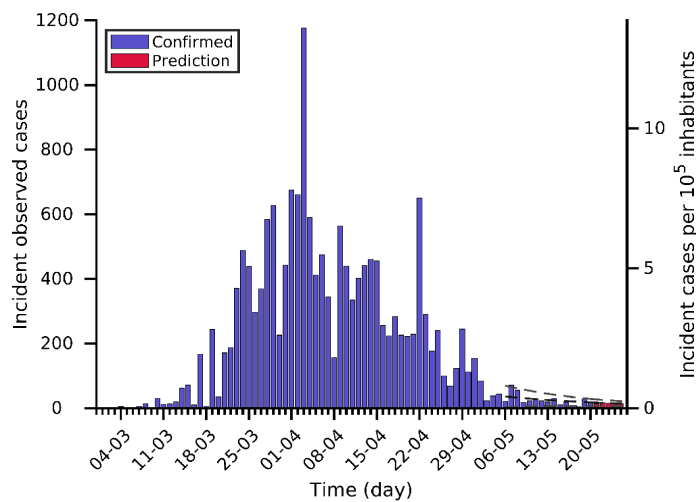
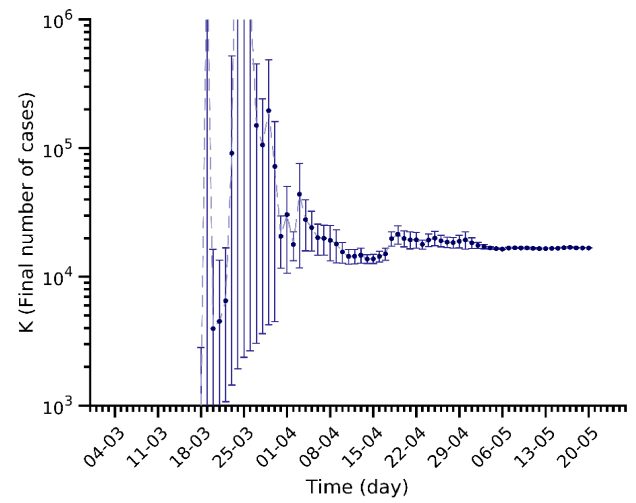
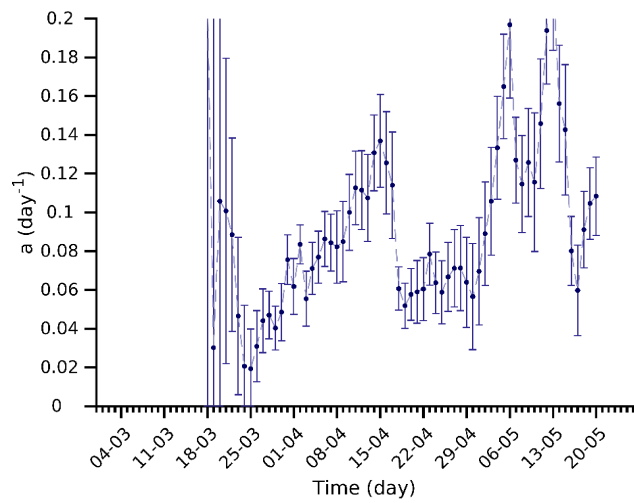
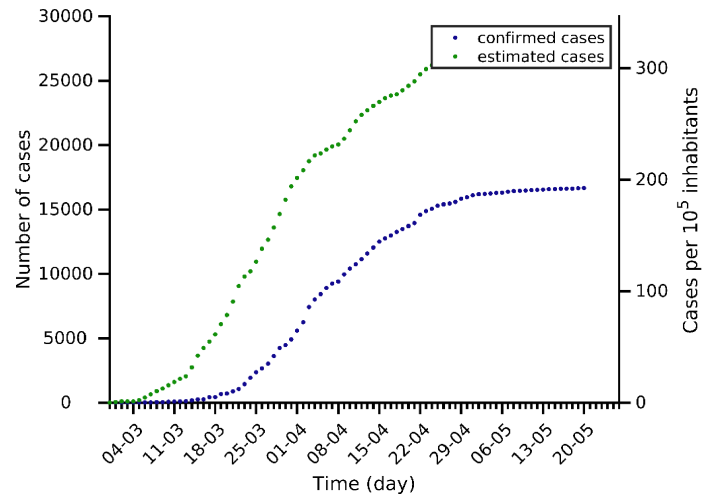
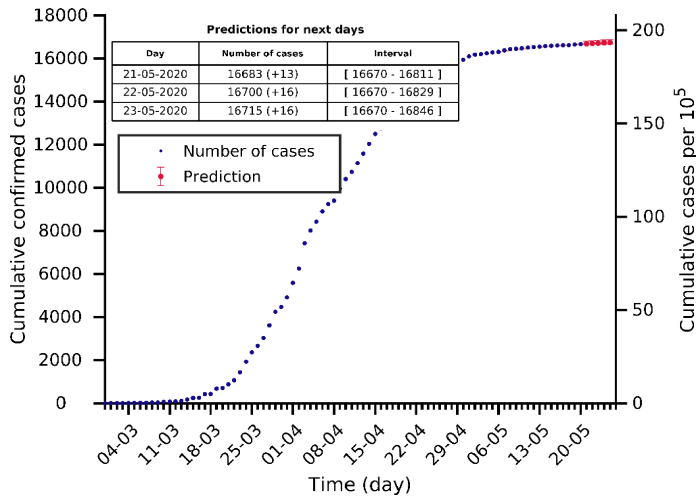
Ecuador 20-05-2020. Population: 17.6M. Current cumulated incidence: 198/10<sup>5</sup>



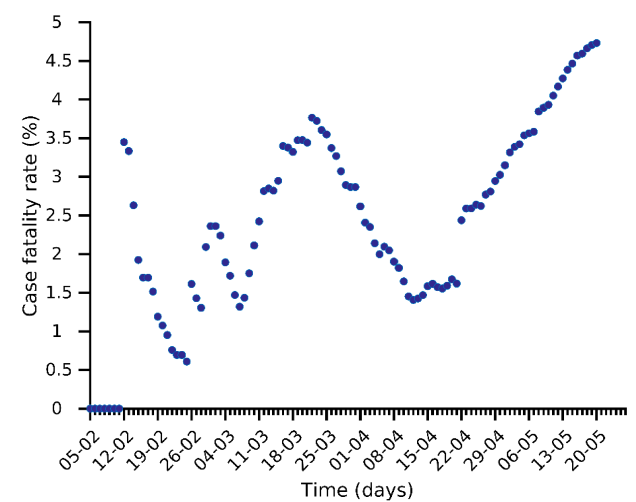
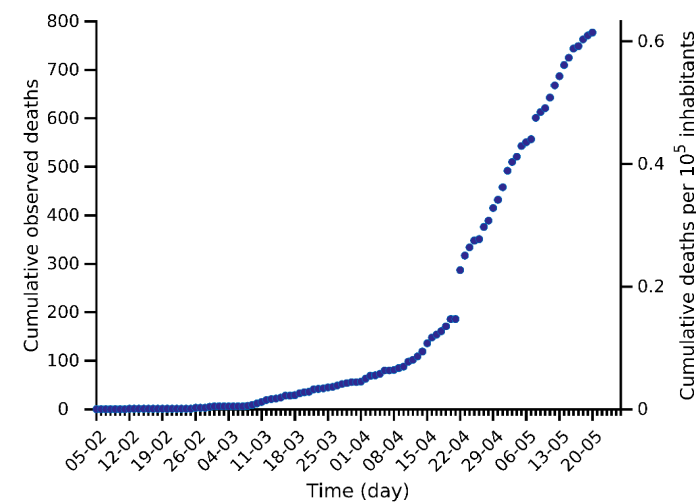
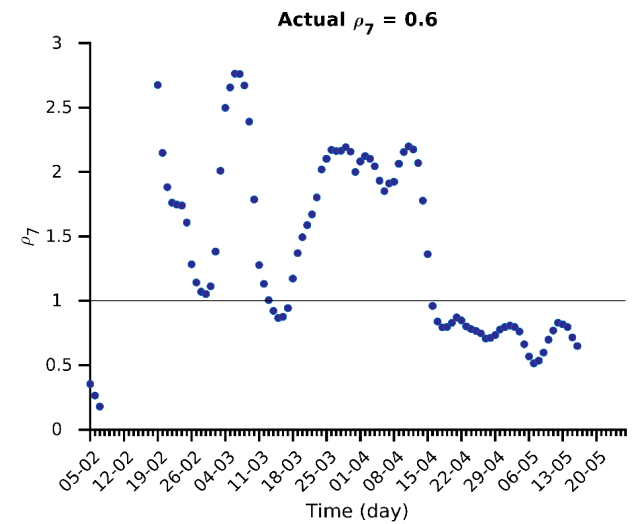
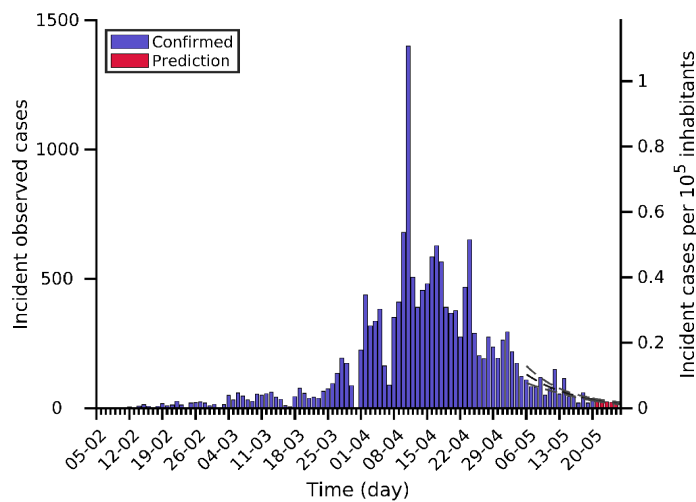
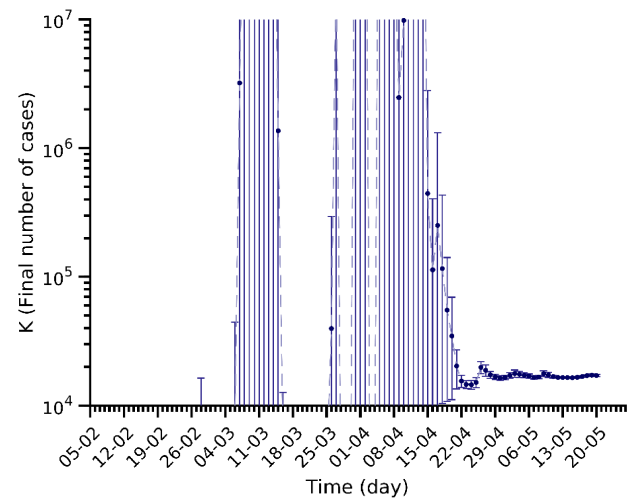
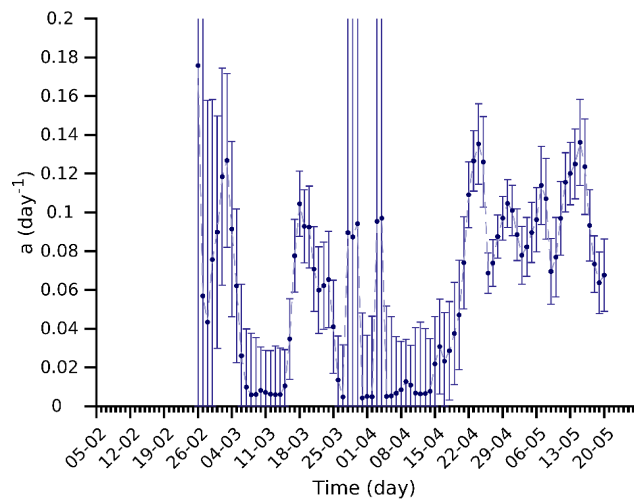
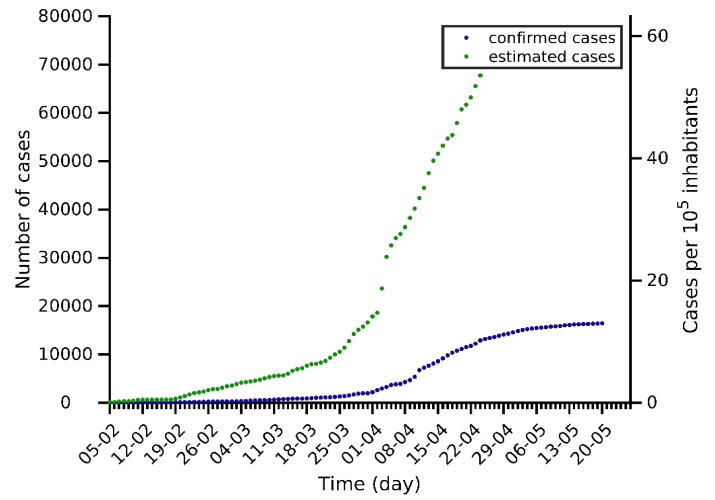
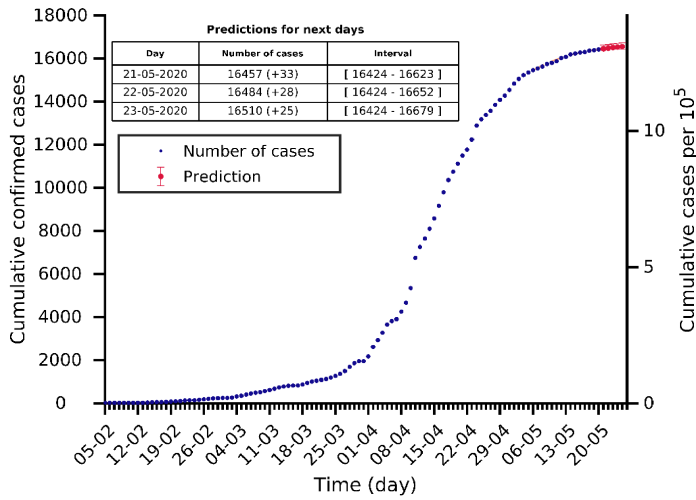
# South Africa 20-05-2020. Population: 59.3M. Current cumulated incidence: 30/10<sup>5</sup>



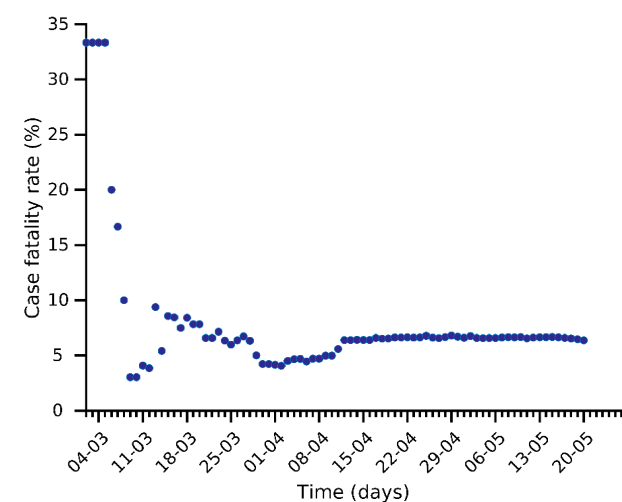
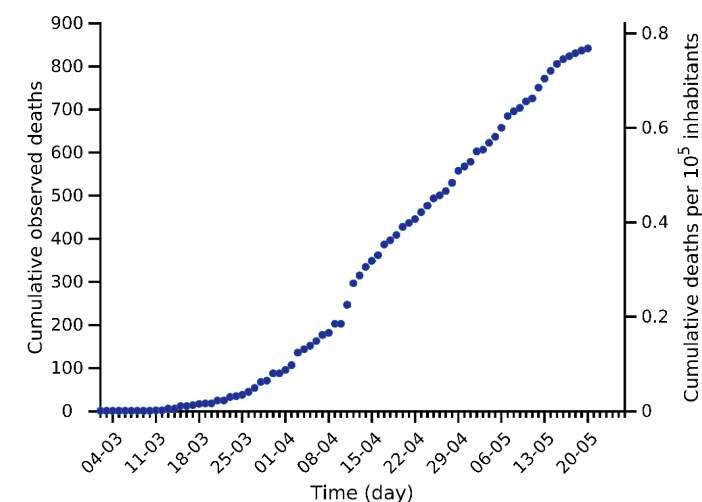
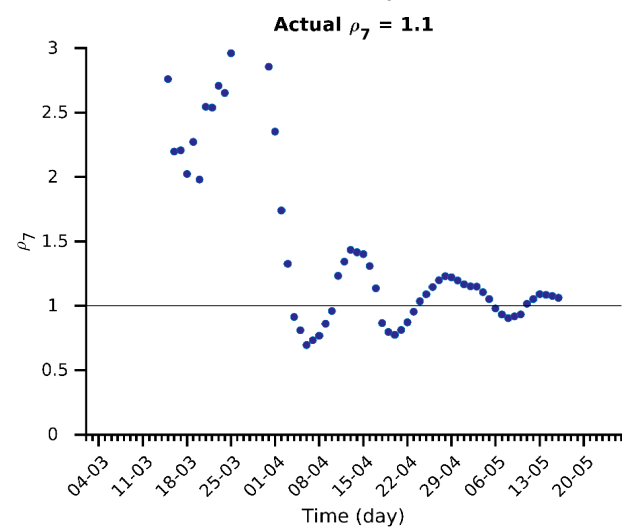
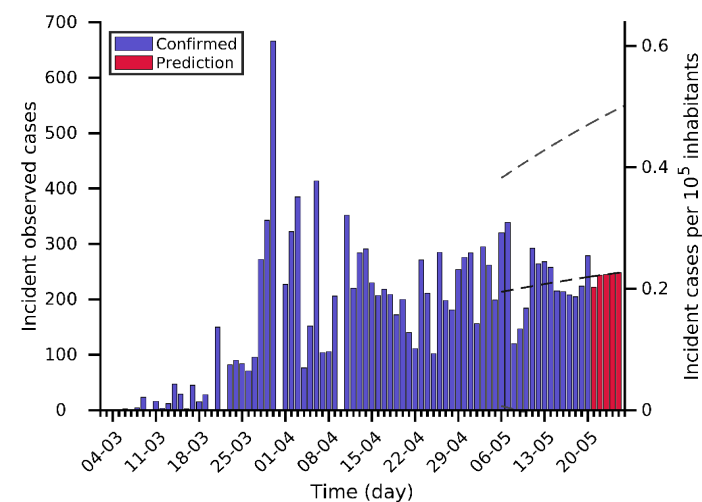
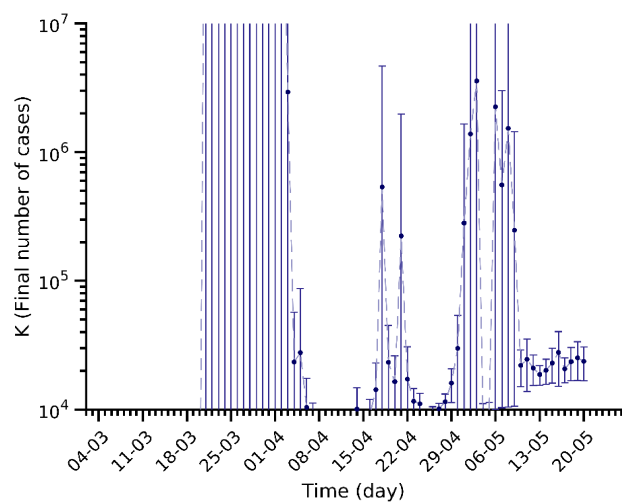
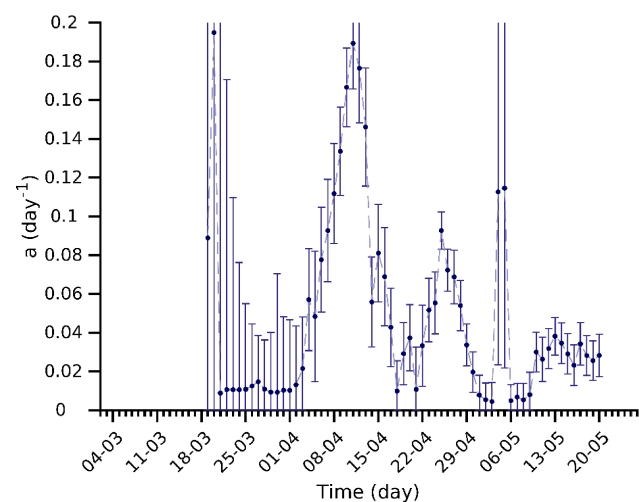
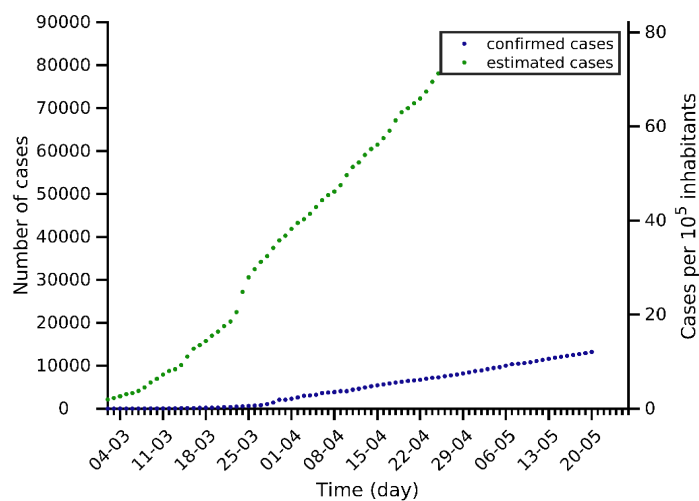
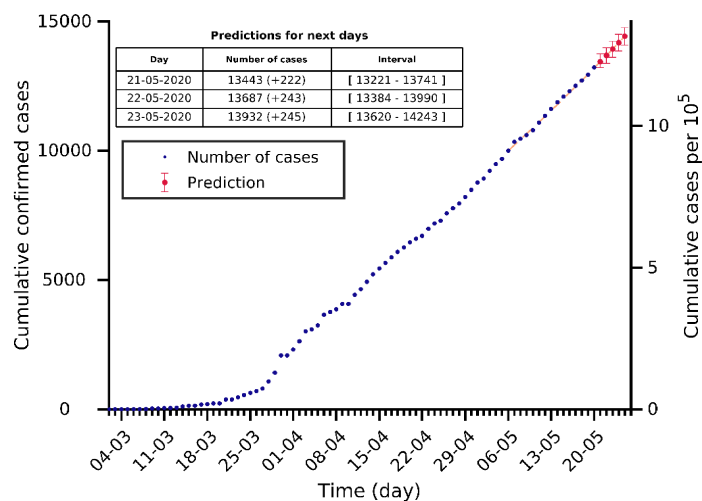
# Israel 20-05-2020. Population: 8.7M. Current cumulated incidence: 193/10<sup>5</sup>



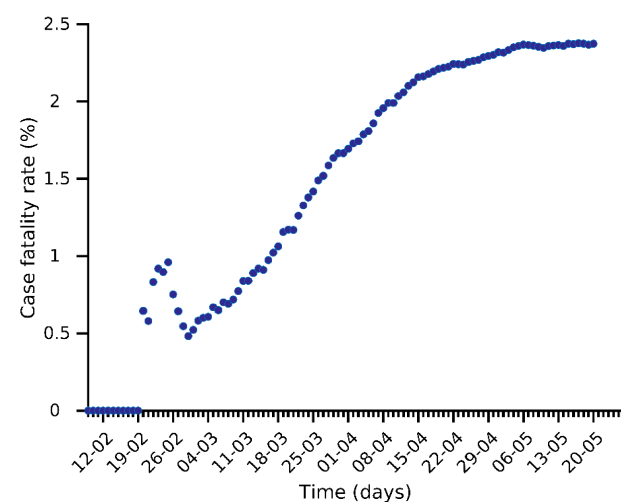
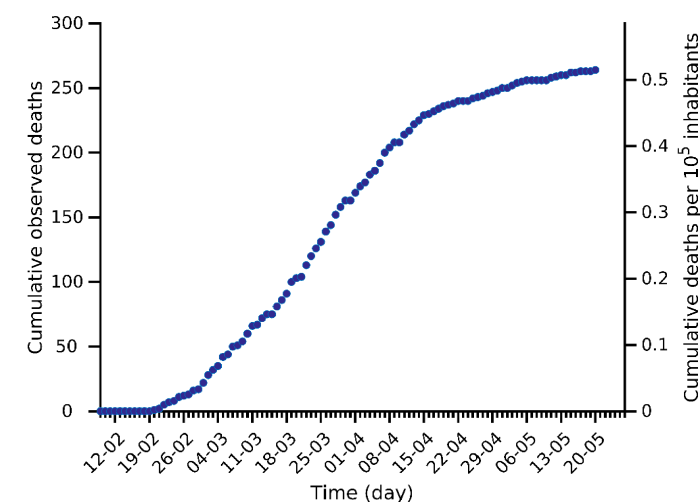
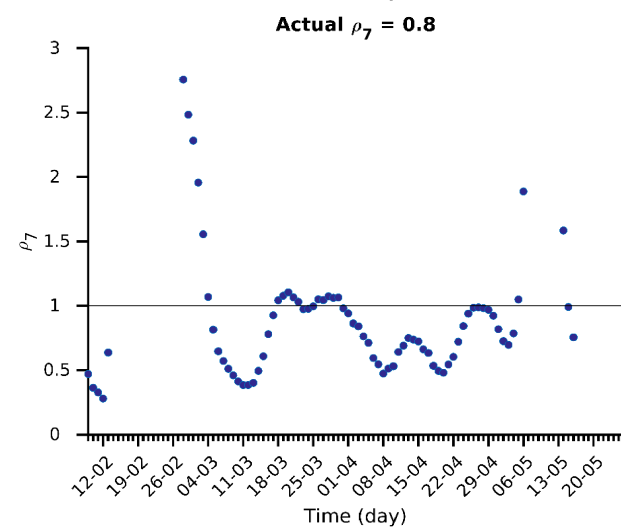
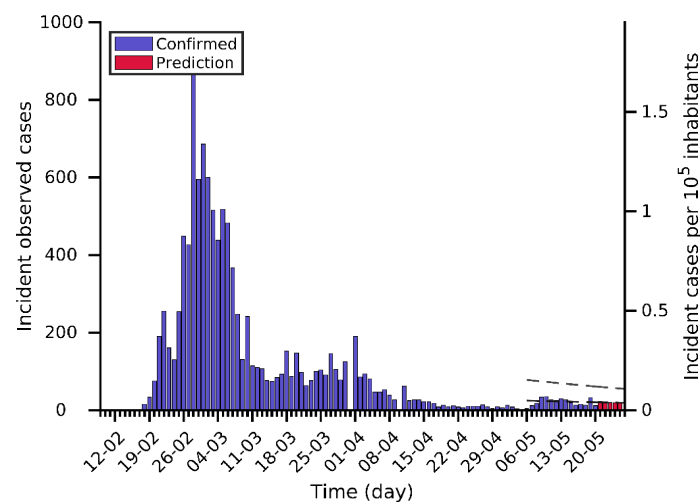
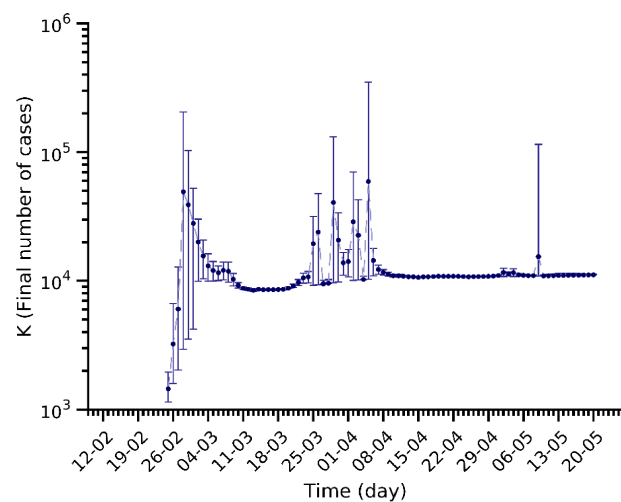
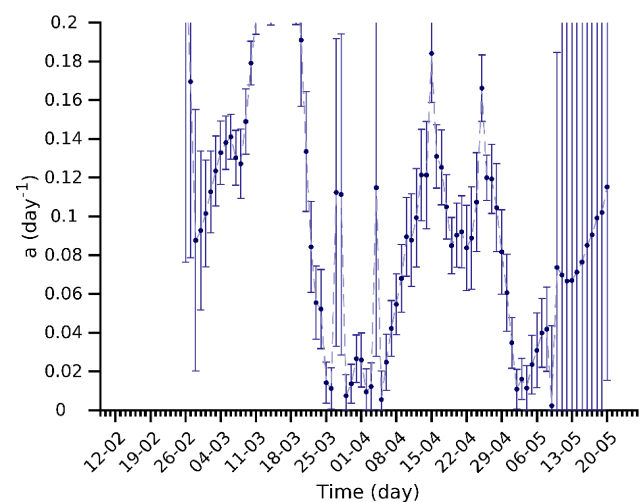
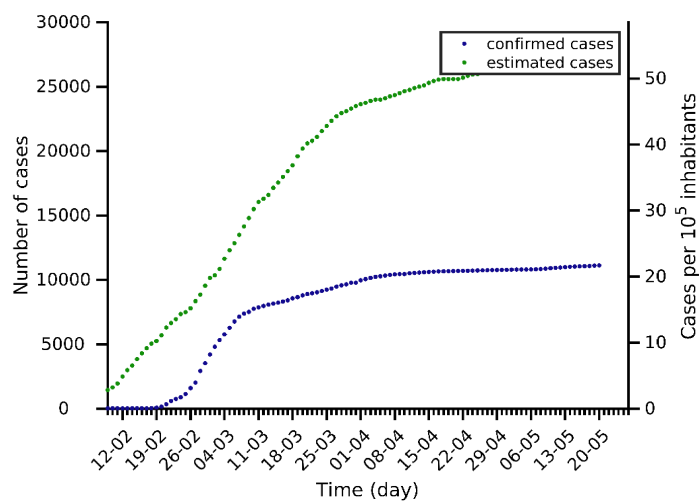
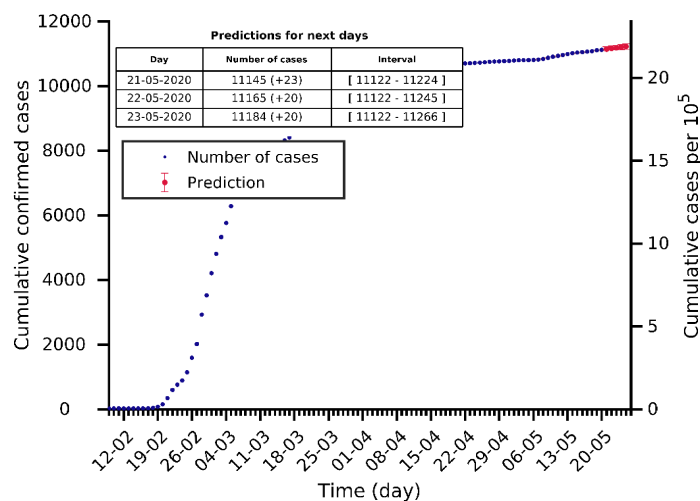
# Japan 20-05-2020. Population: 126.5M. Current cumulated incidence: 13/10<sup>5</sup>



# Philippines 20-05-2020. Population: 109.6M. Current cumulated incidence: 12/10<sup>5</sup>

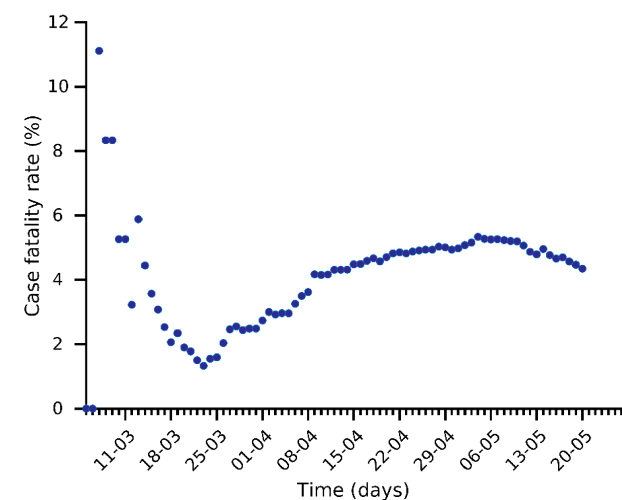
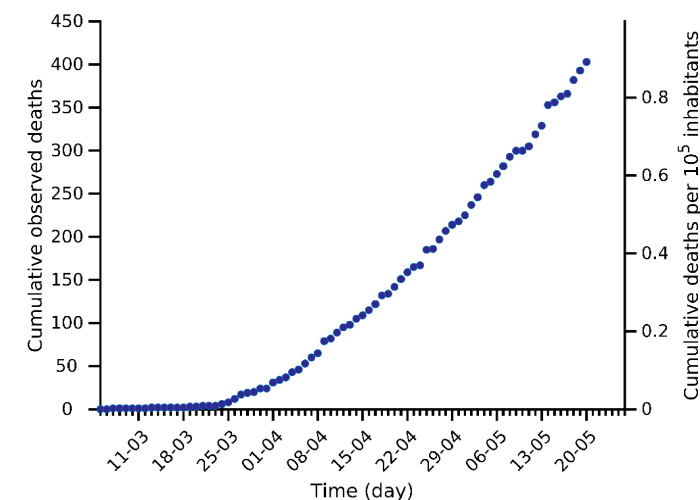
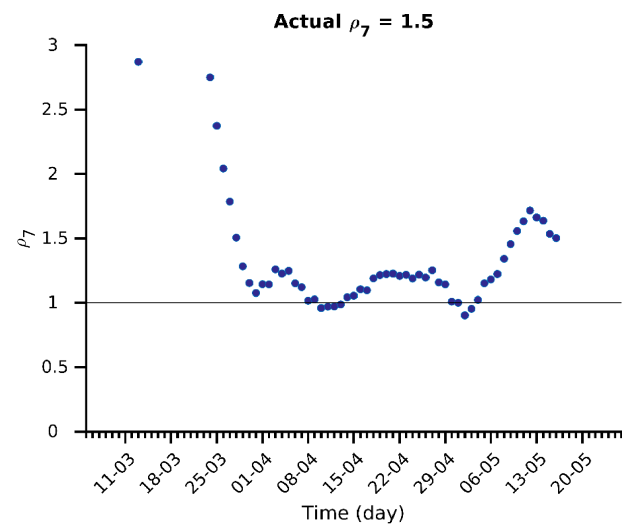
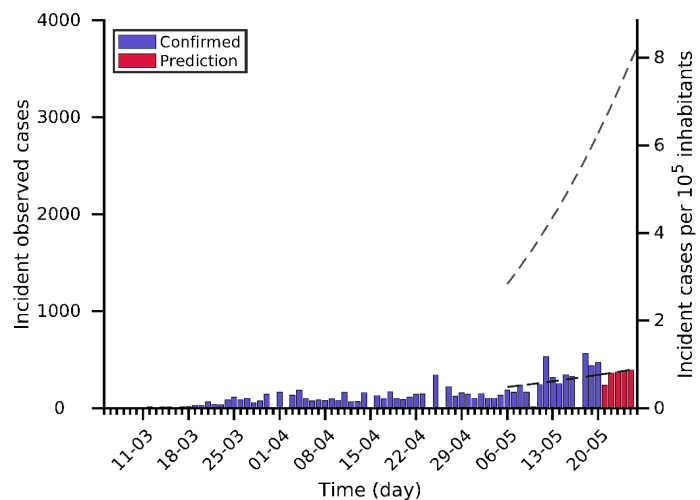
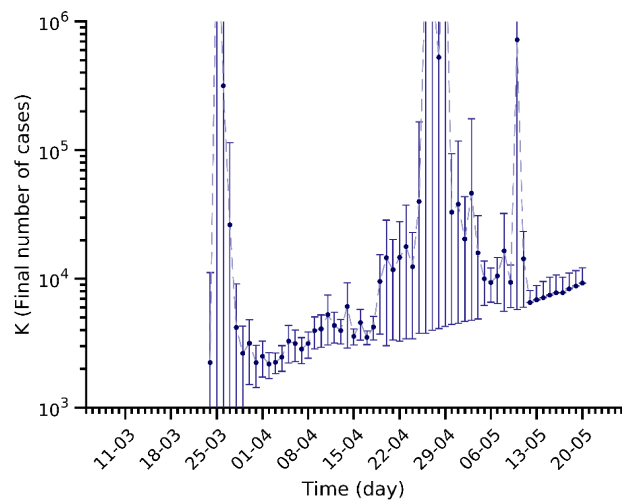
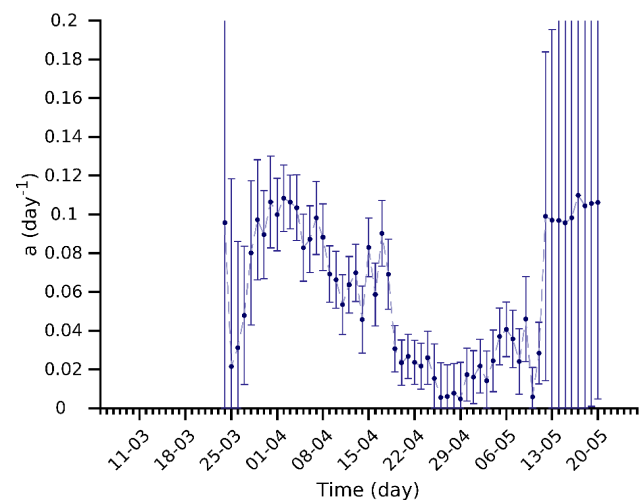
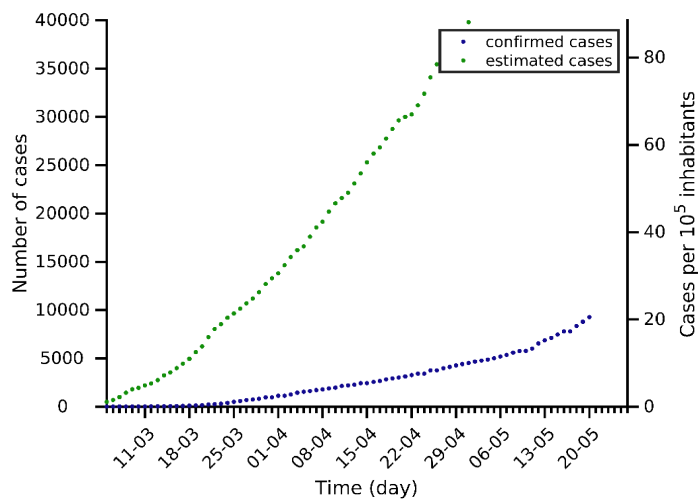
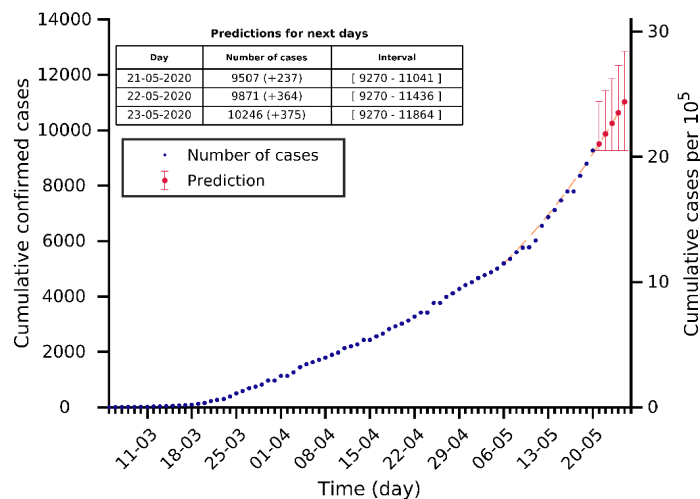


# South Korea 20-05-2020. Population: 51.3M. Current cumulated incidence: 22/10<sup>5</sup>

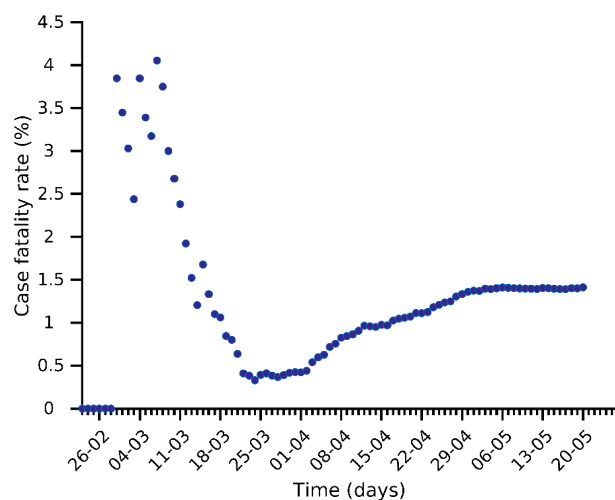
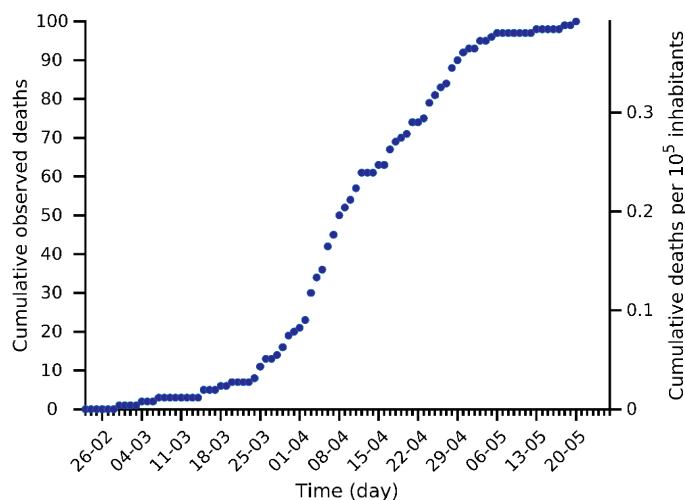
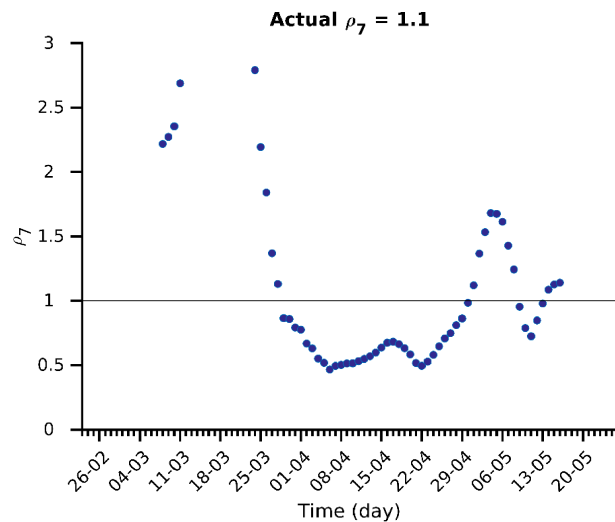
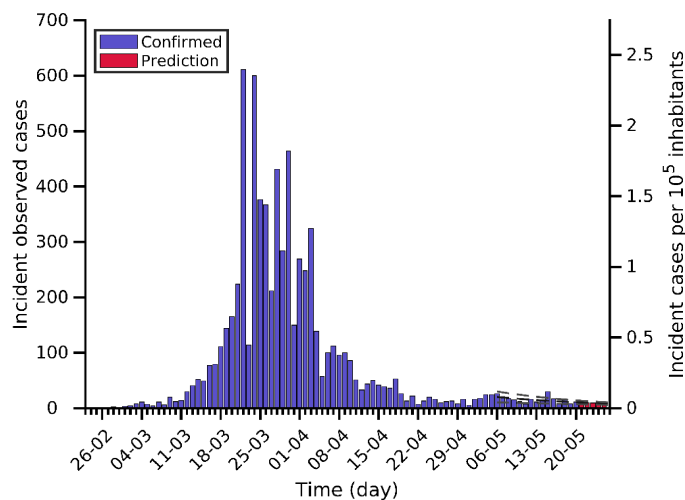
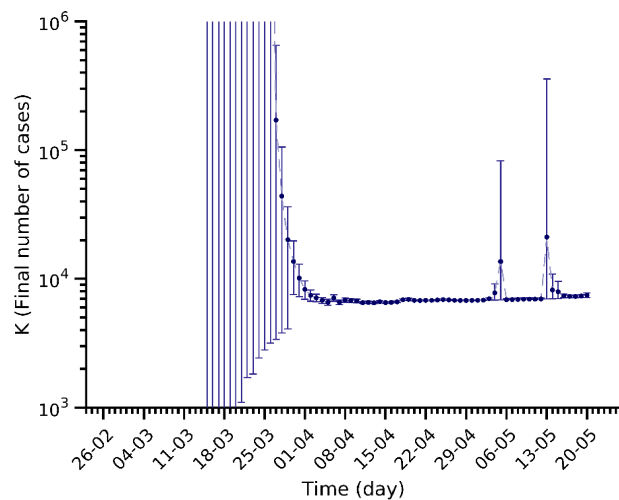
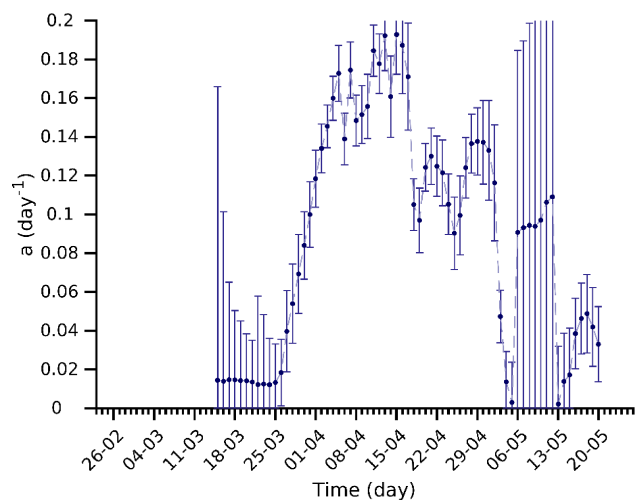
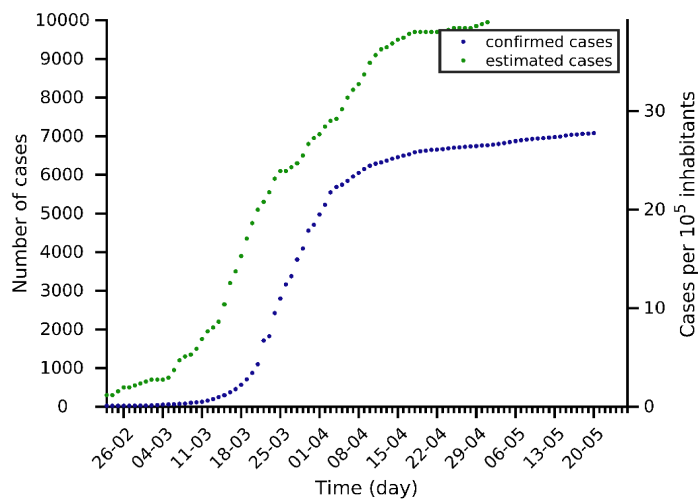
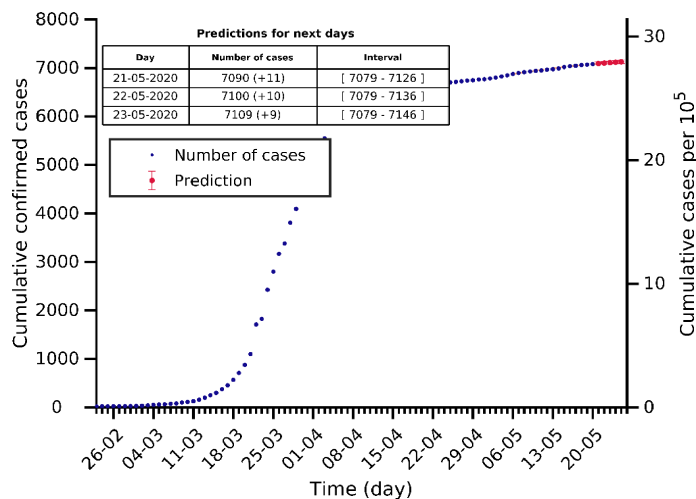




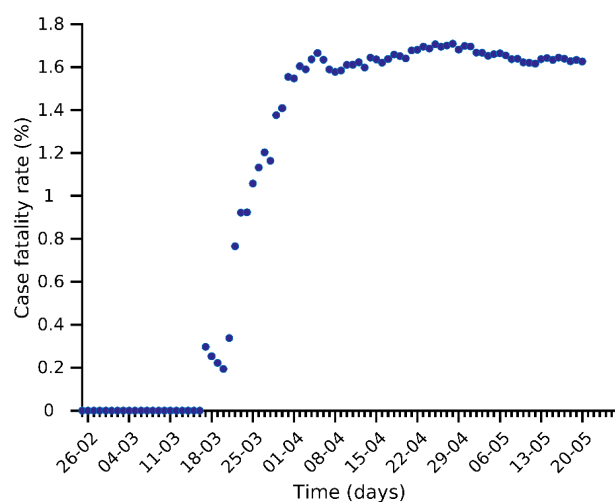
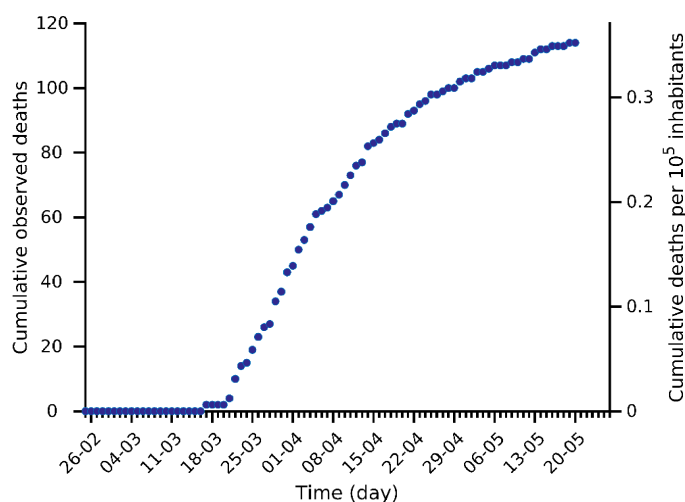
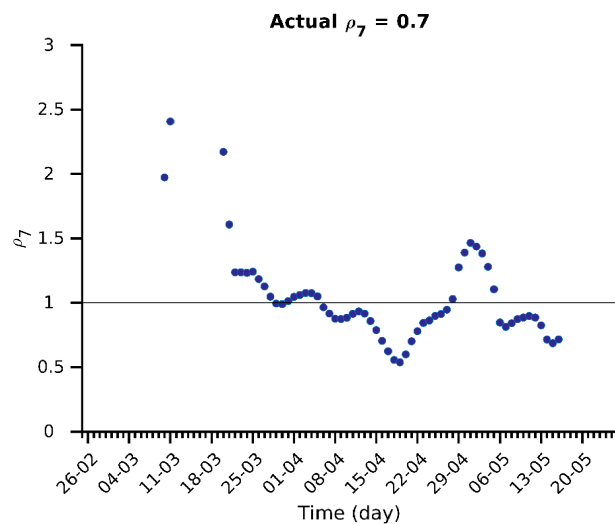
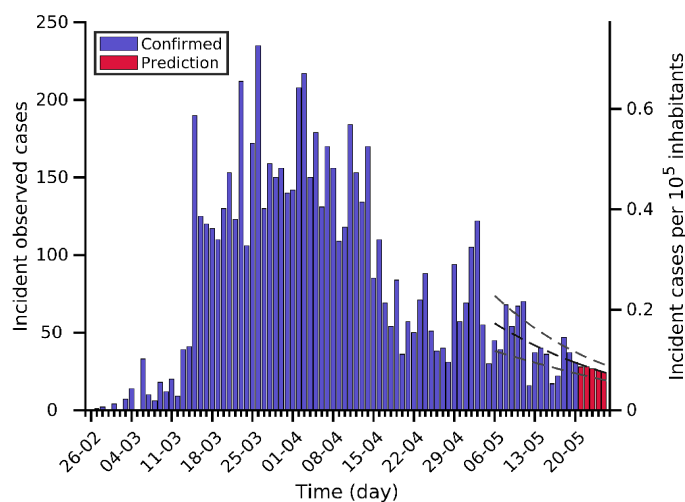
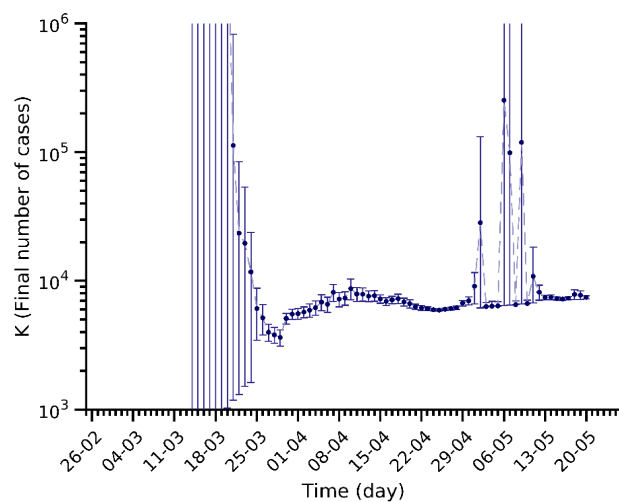
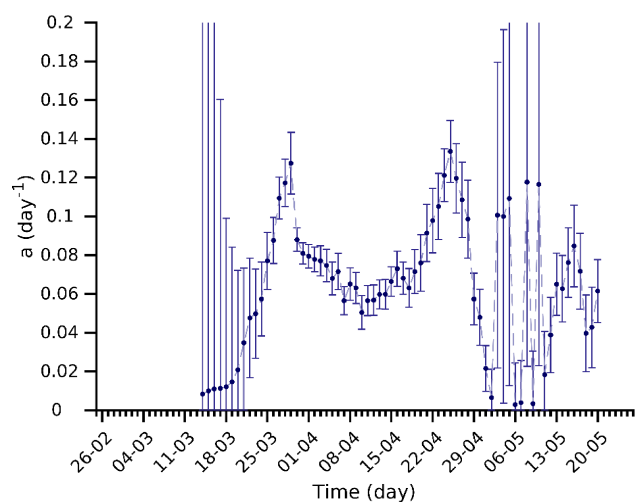
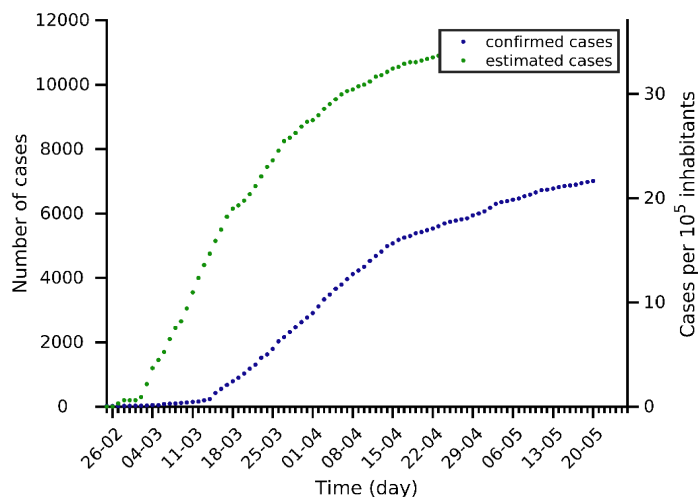
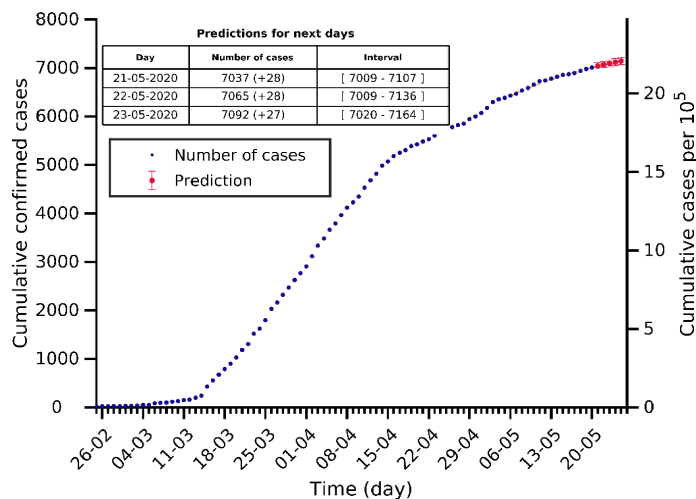
# Argentina 20-05-2020. Population: 45.2M. Current cumulated incidence: 21/10<sup>5</sup>



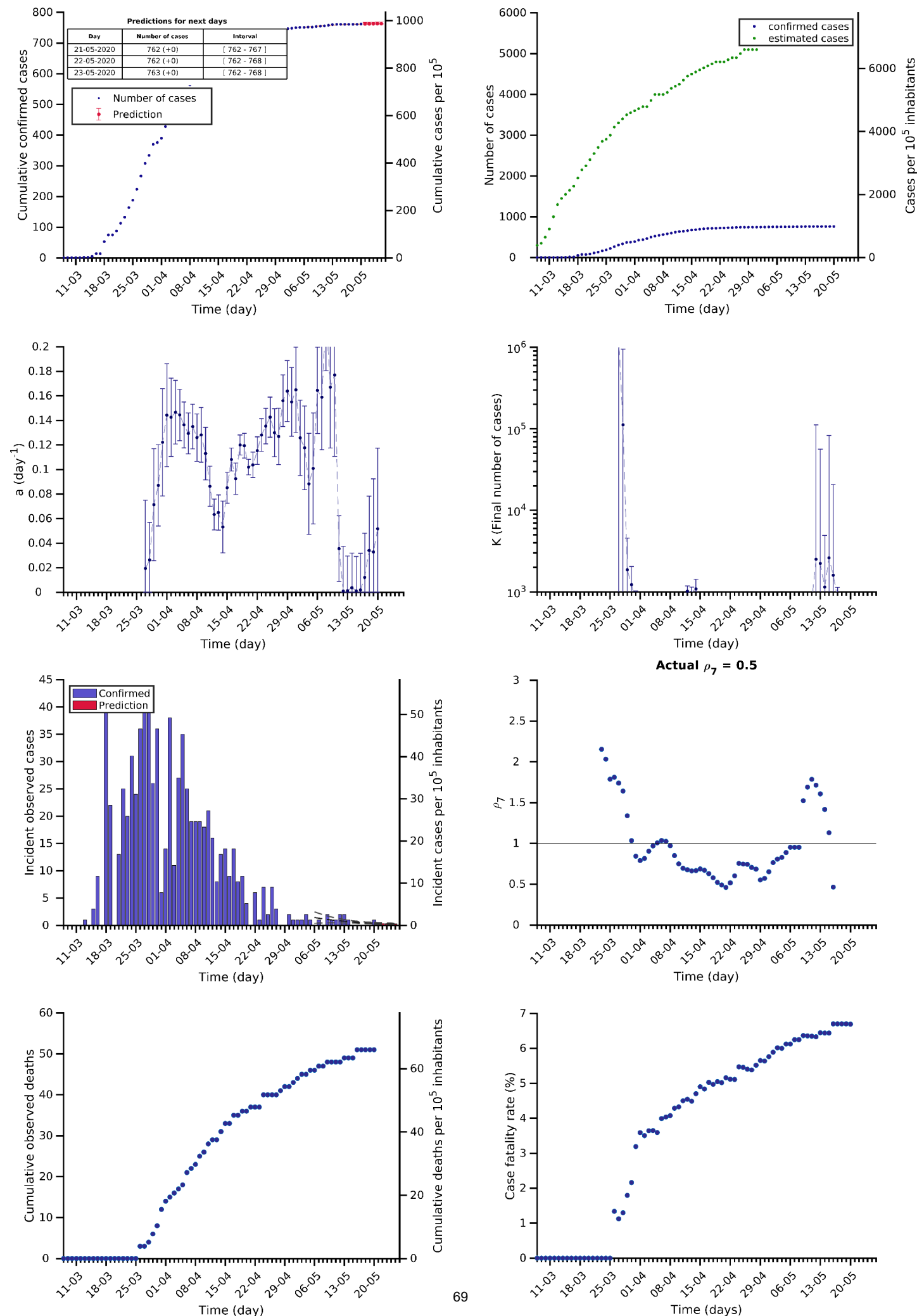
# Australia 20-05-2020. Population: 25.5M. Current cumulated incidence: $28/10^5$



# Malaysia 20-05-2020. Population: 32.4M. Current cumulated incidence: 22/10<sup>5</sup>



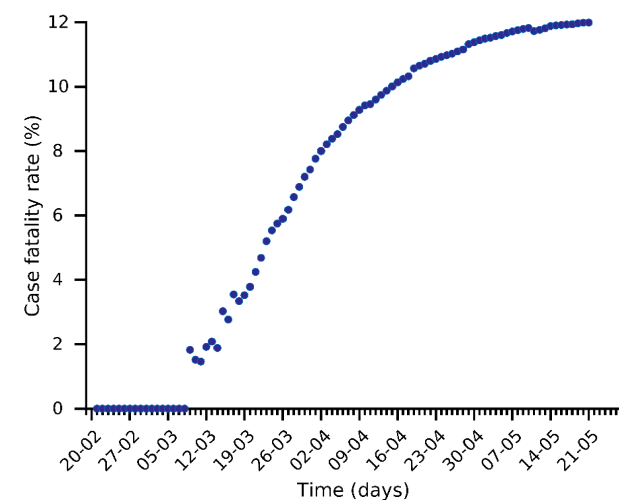
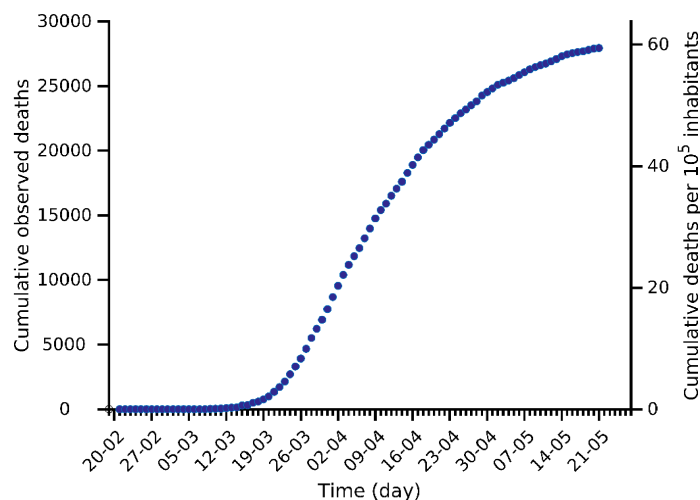
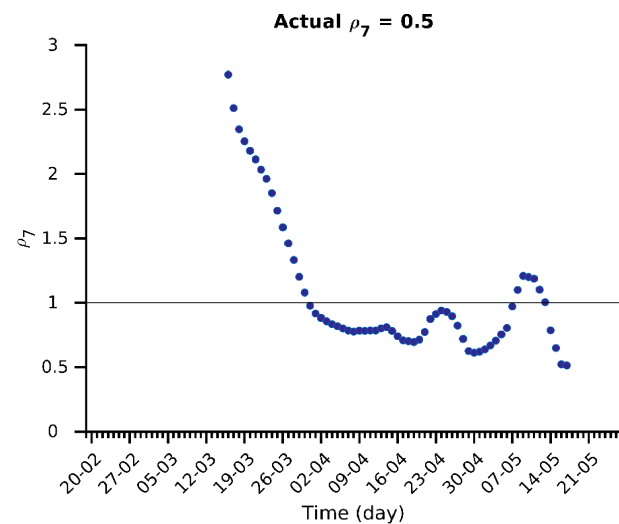
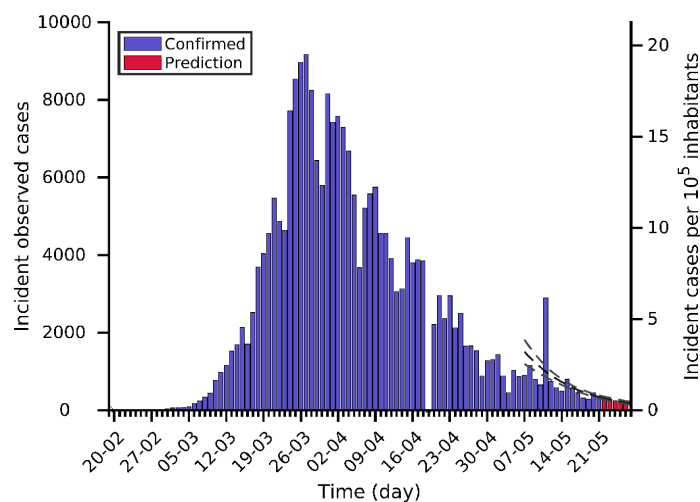
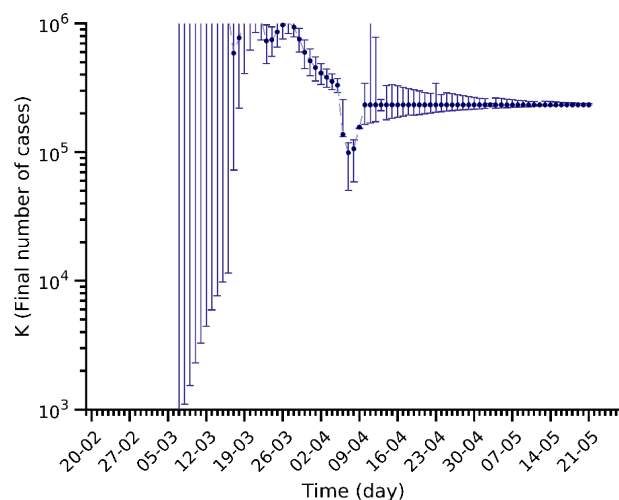
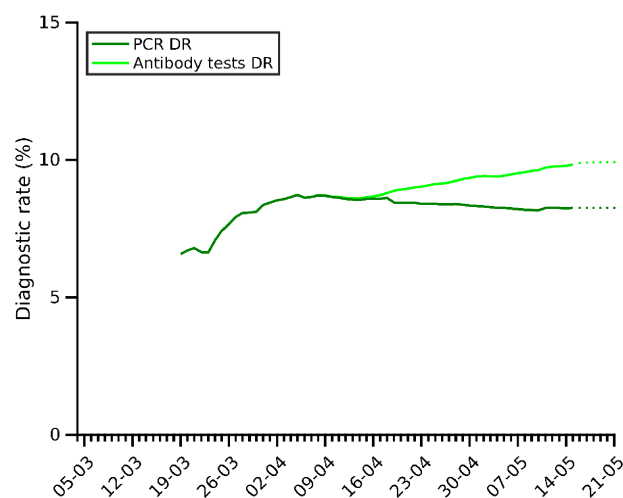
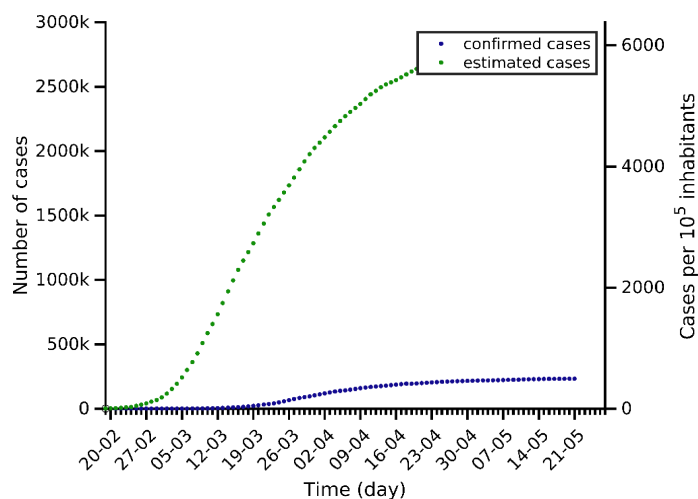
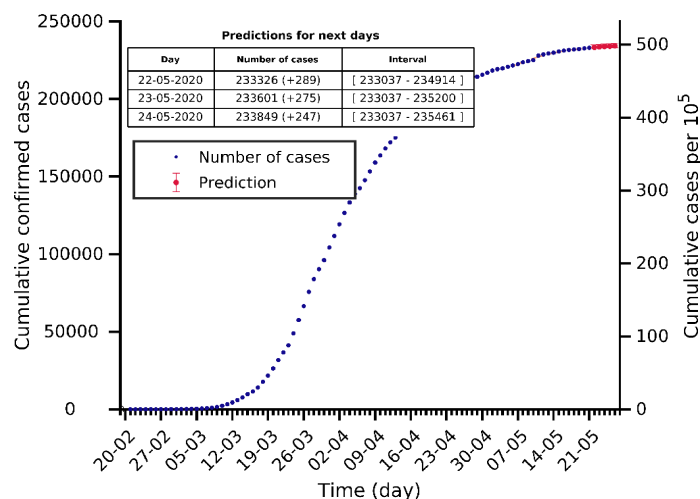
# Andorra 20-05-2020. Population: 0.1M. Current cumulated incidence: 986/10<sup>5</sup>



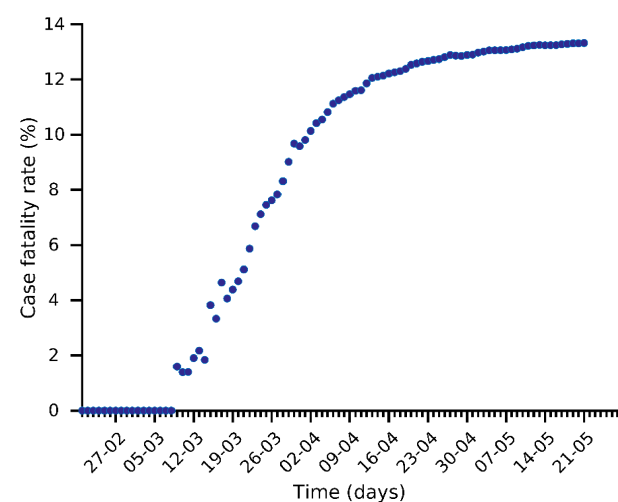
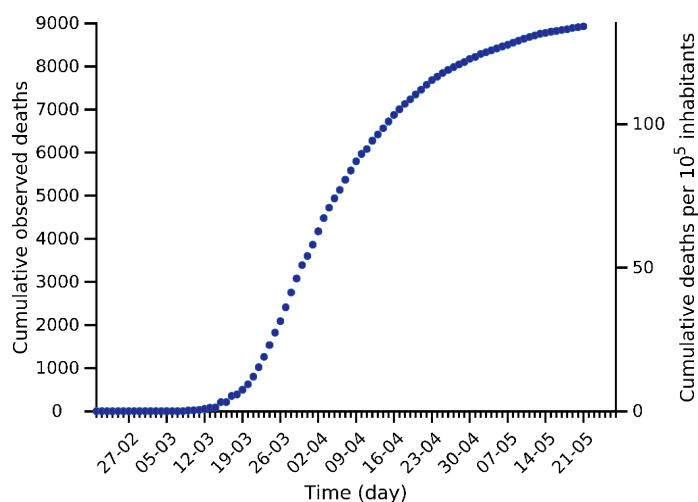
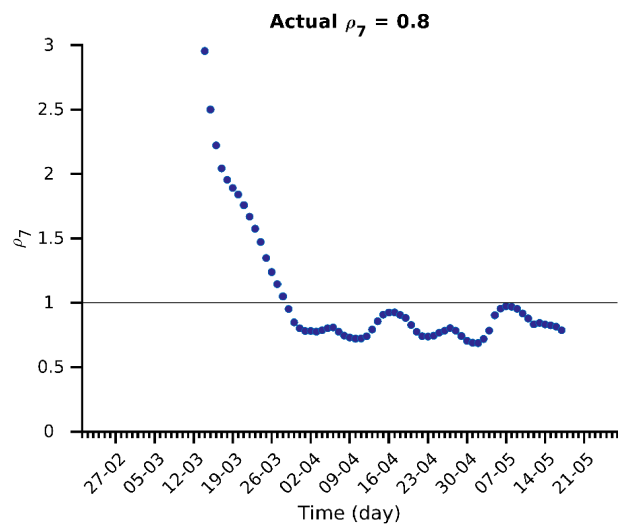
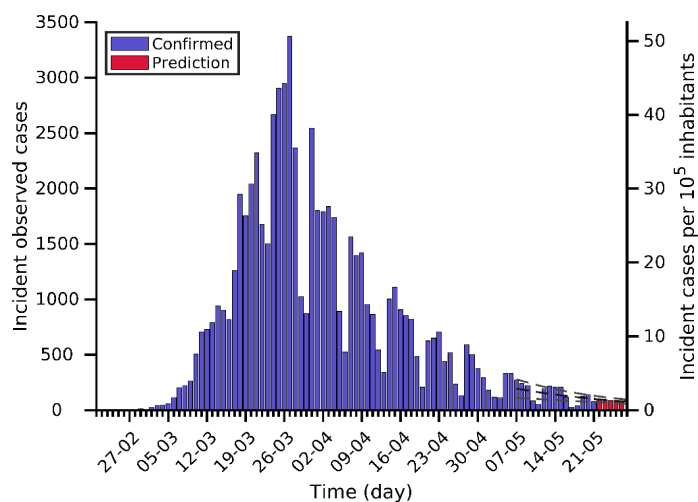
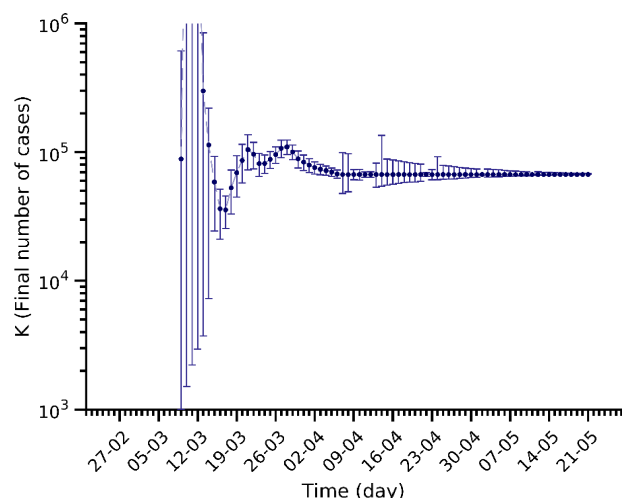
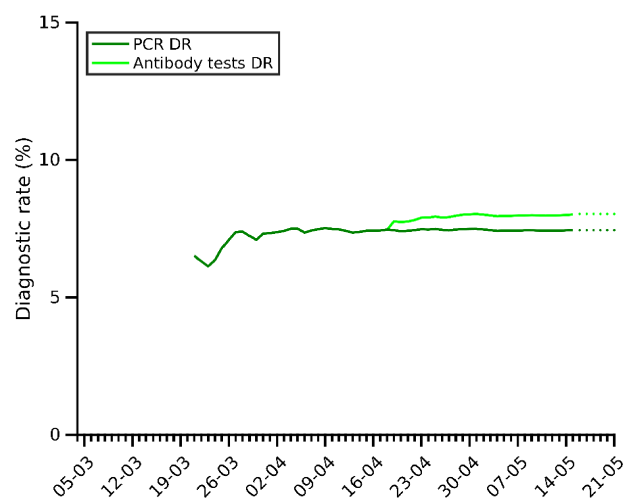
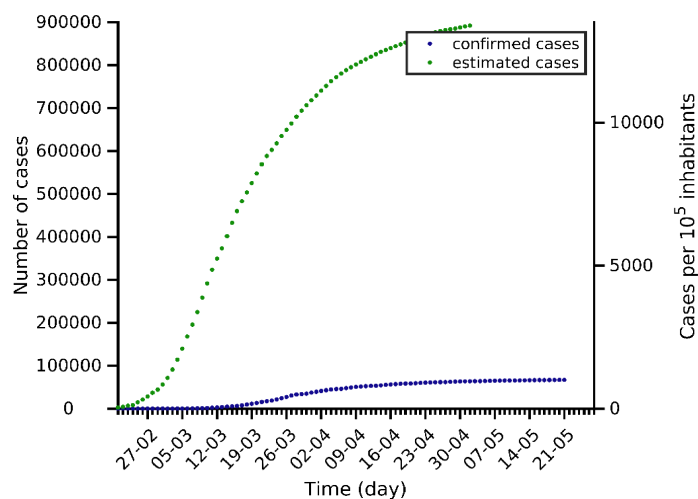
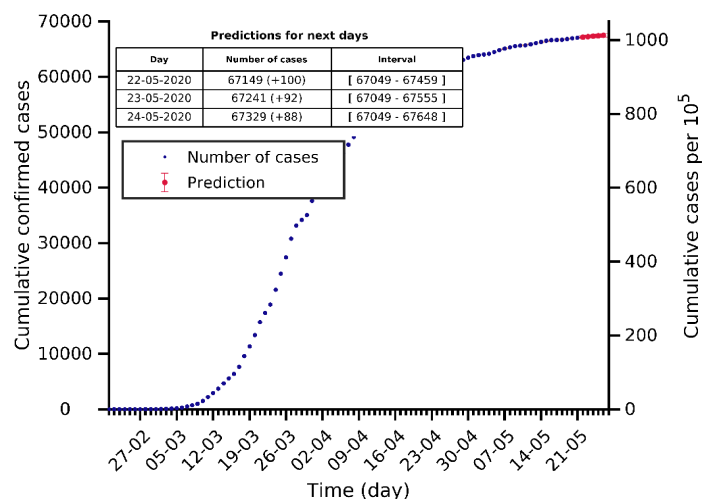
### **(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities**

**WARNING: Data from Catalunya and Spain are  
provisional, pending on the indication to locate  
2715 old cases.**

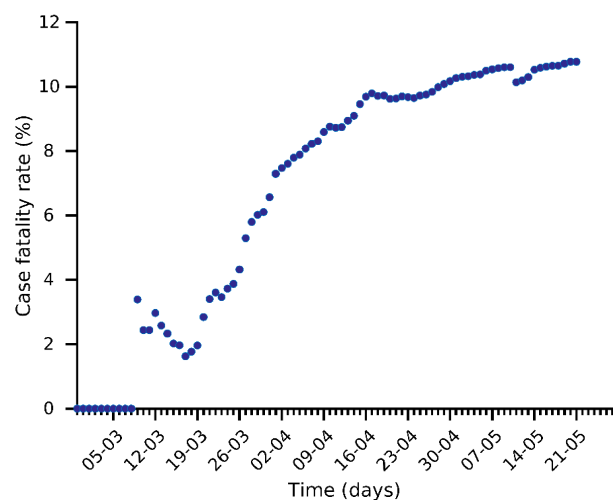
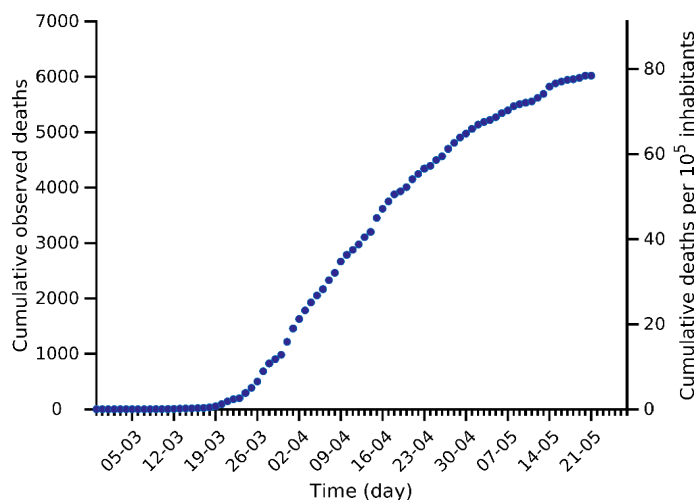
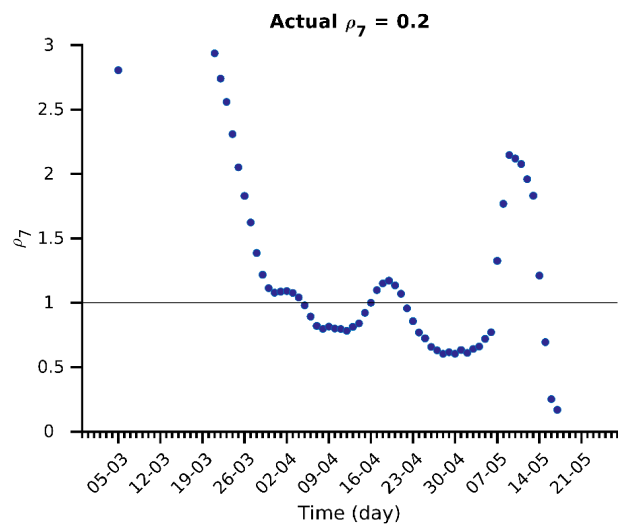
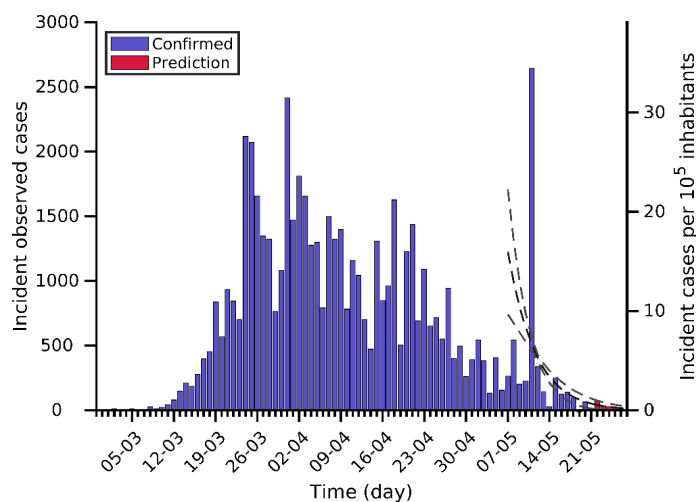
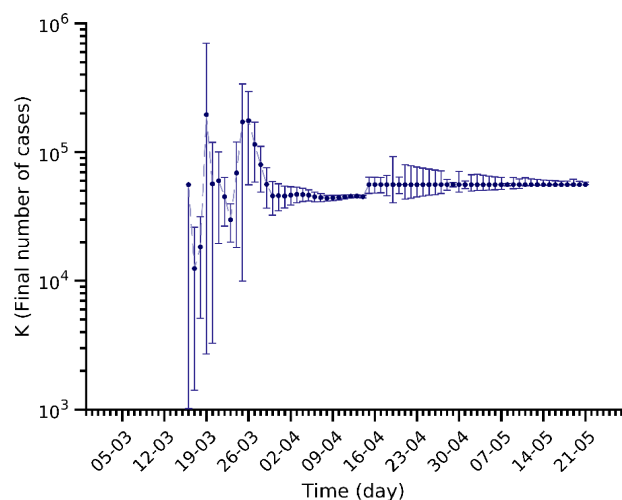
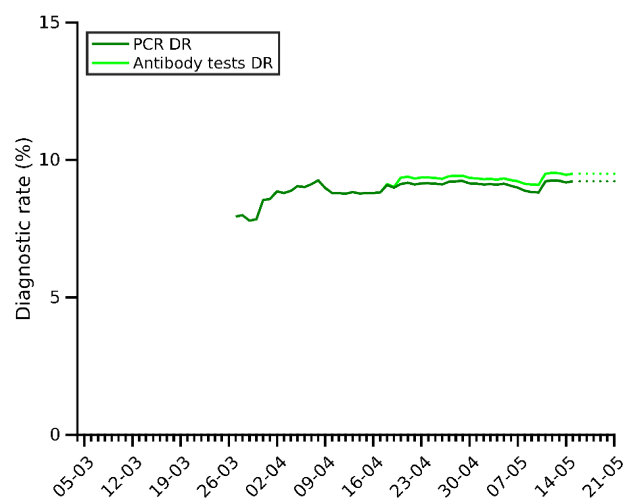
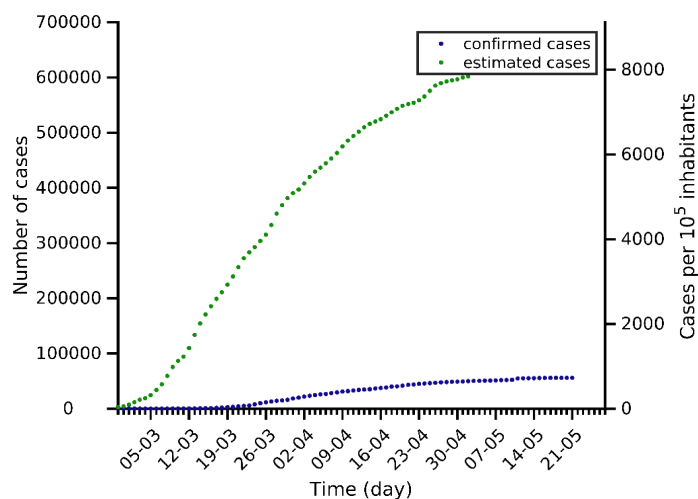
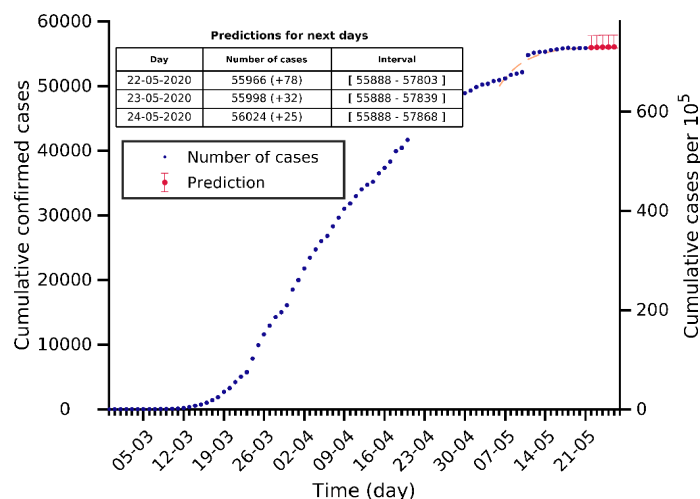
# Spain 21-05-2020. Population: 47.0M. Current cumulated incidence: 496/10<sup>5</sup>



# Madrid 21-05-2020. Population: 6.7M. Current cumulated incidence: 1006/10<sup>5</sup>

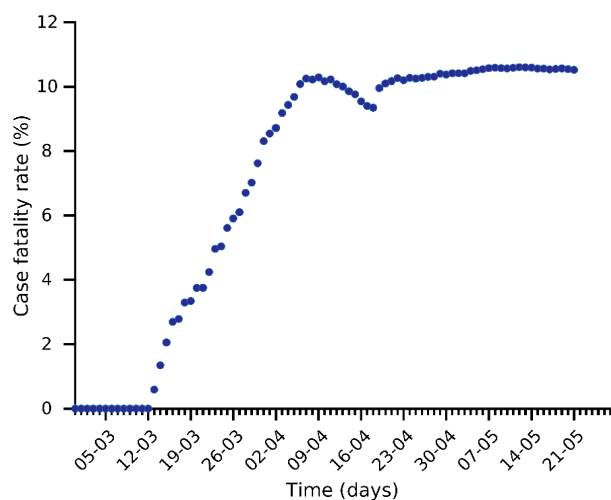
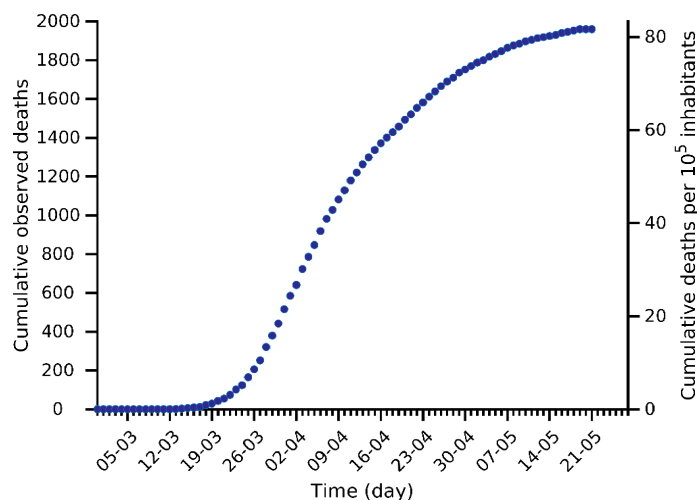
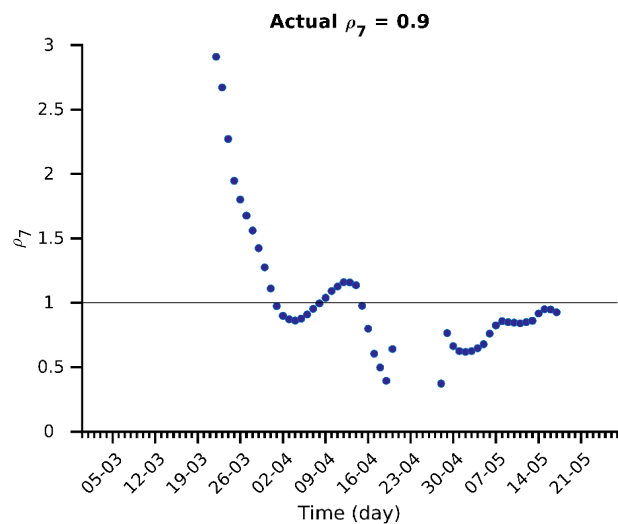
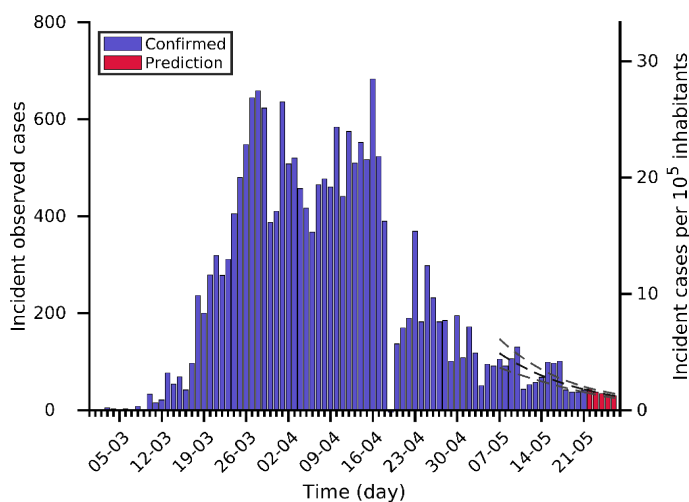
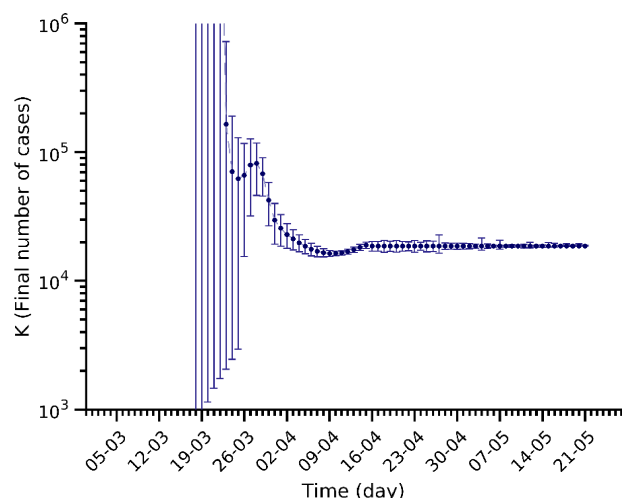
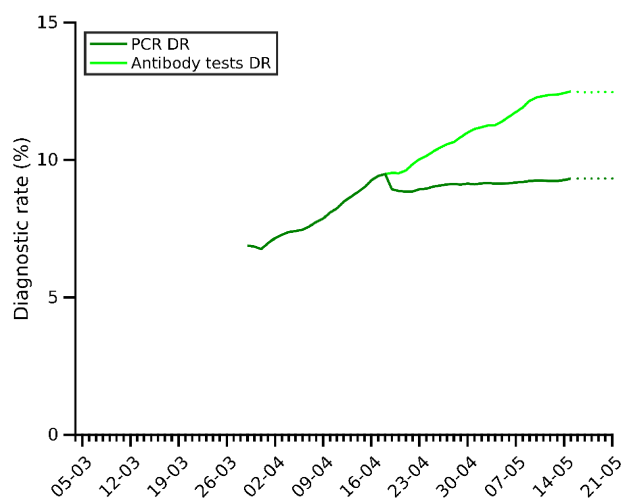
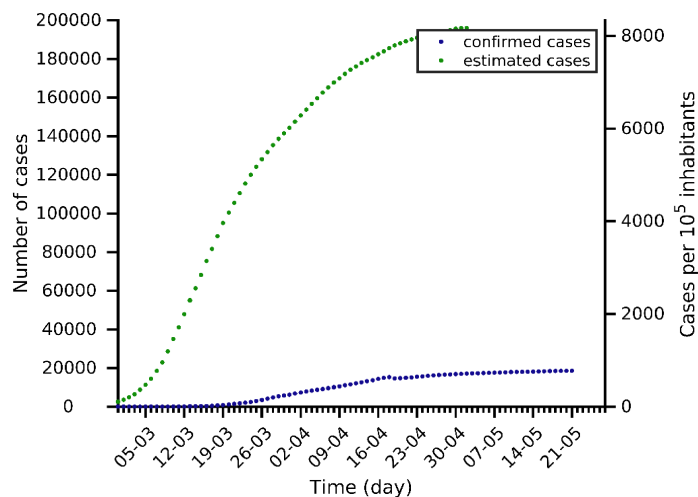
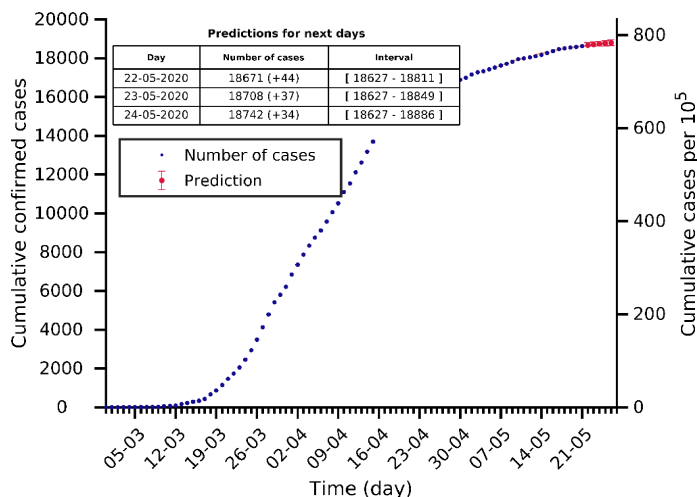


# Catalunya 21-05-2020. Population: 7.7M. Current cumulated incidence: 728/10<sup>5</sup>

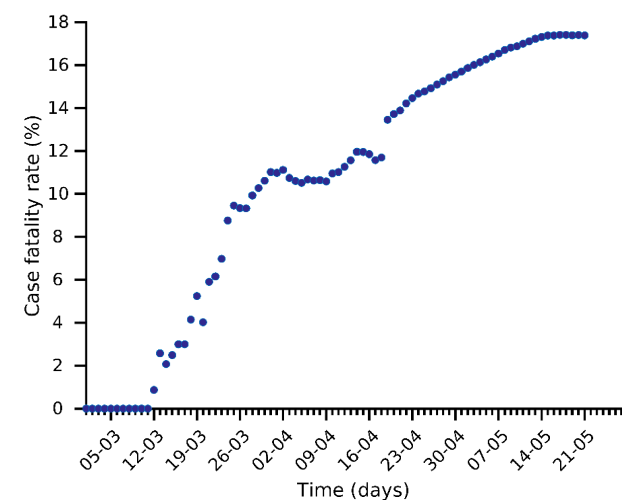
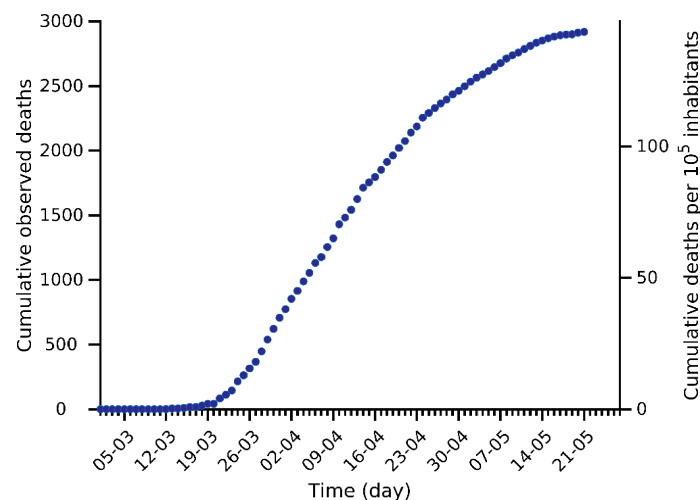
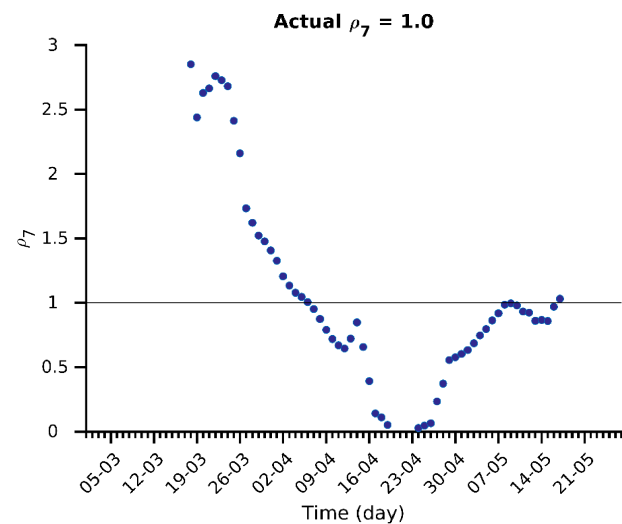
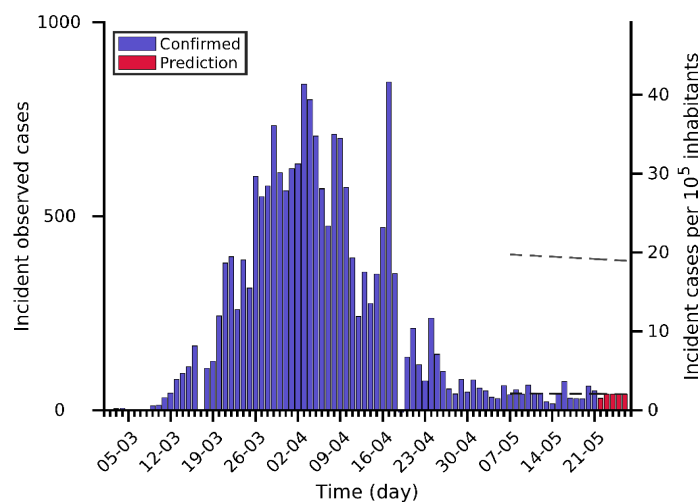
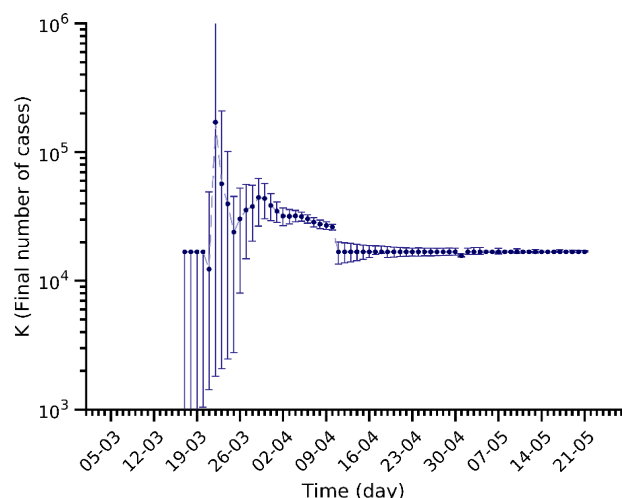
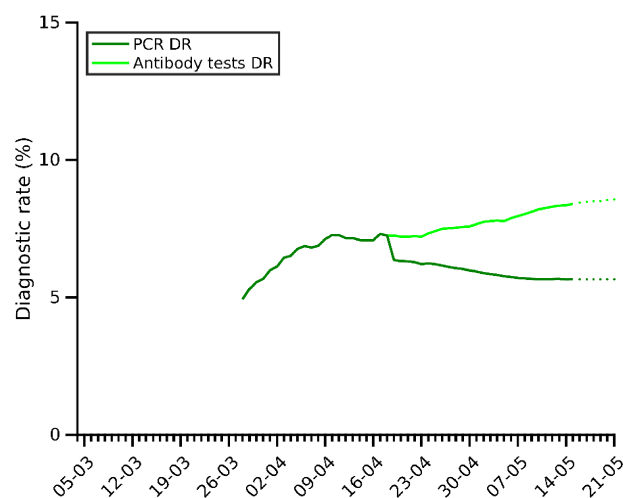
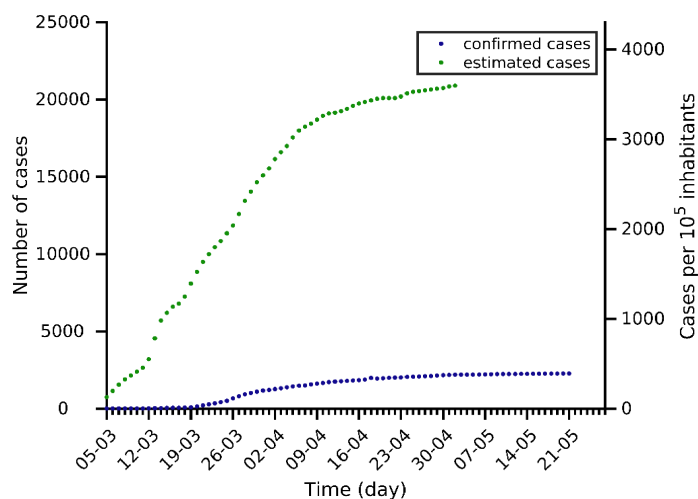
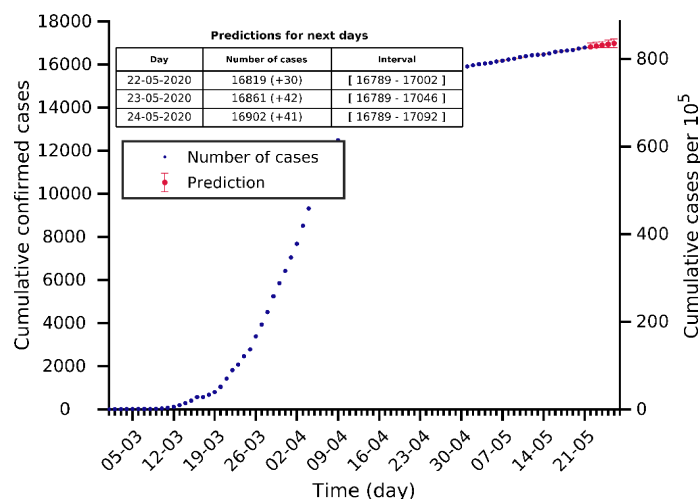




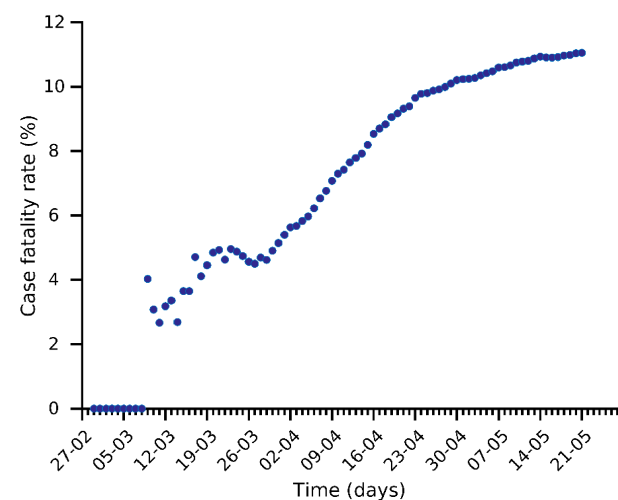
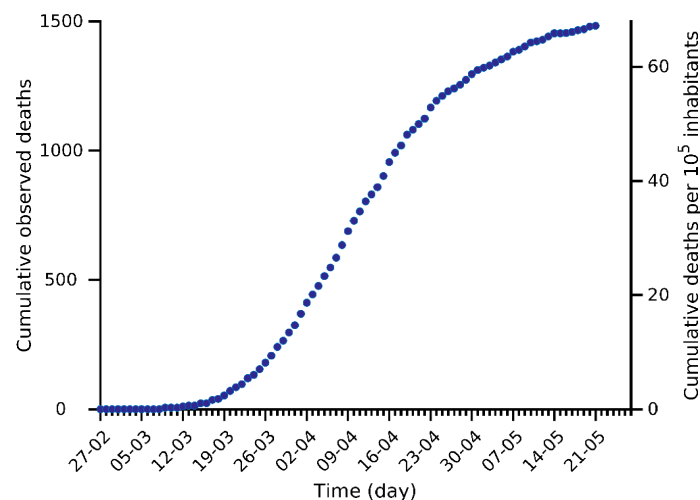
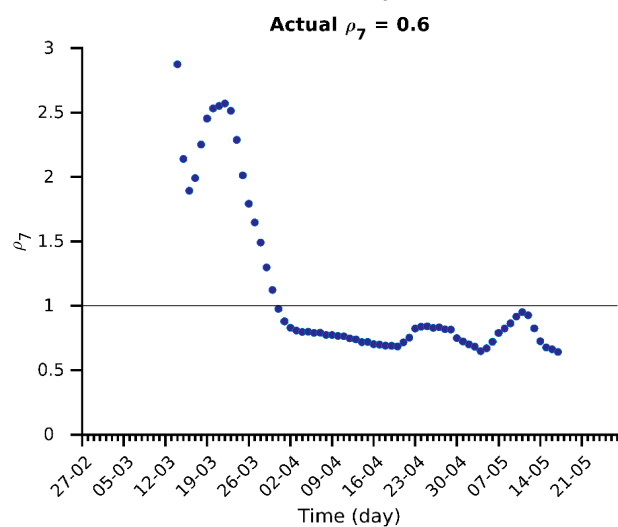
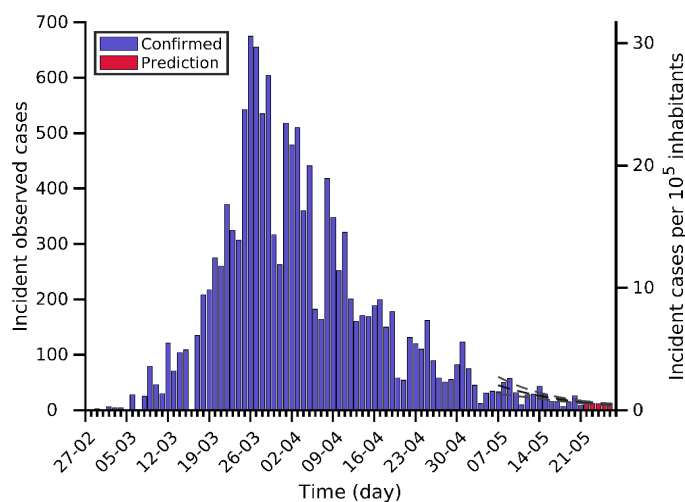
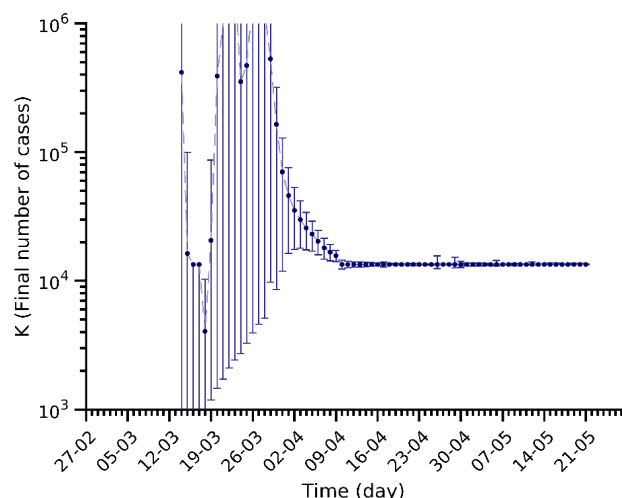
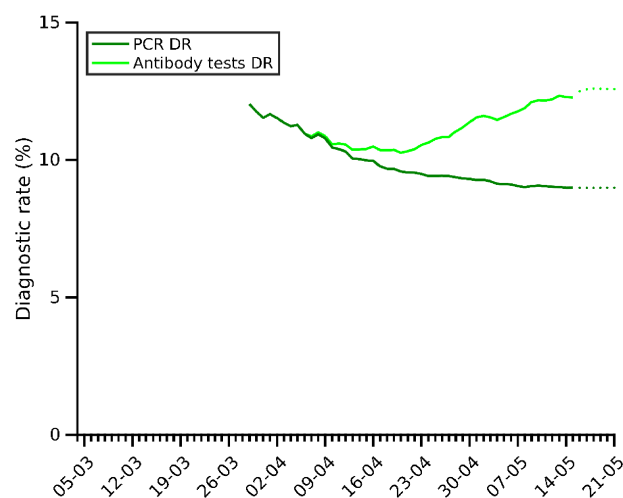
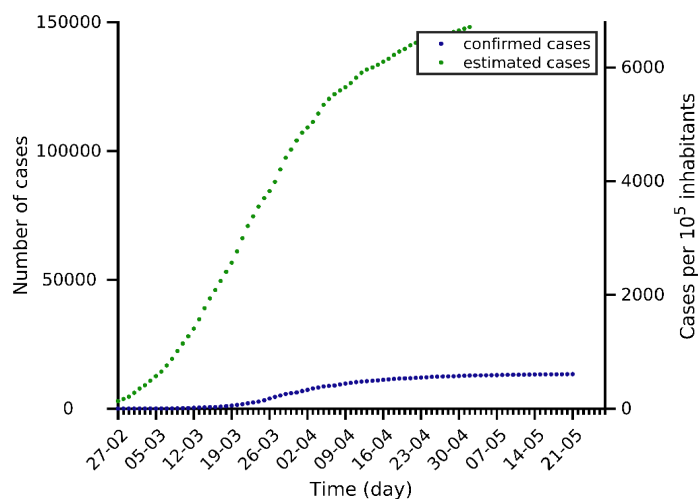
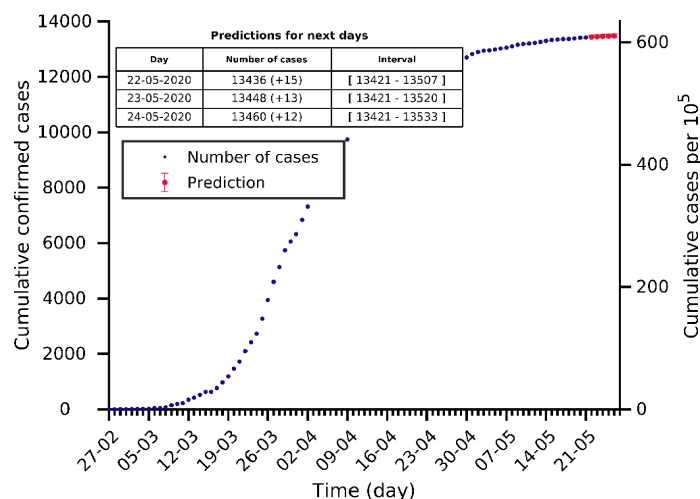
# Castilla Leon 21-05-2020. Population: 2.4M. Current cumulated incidence: 776/10<sup>5</sup>



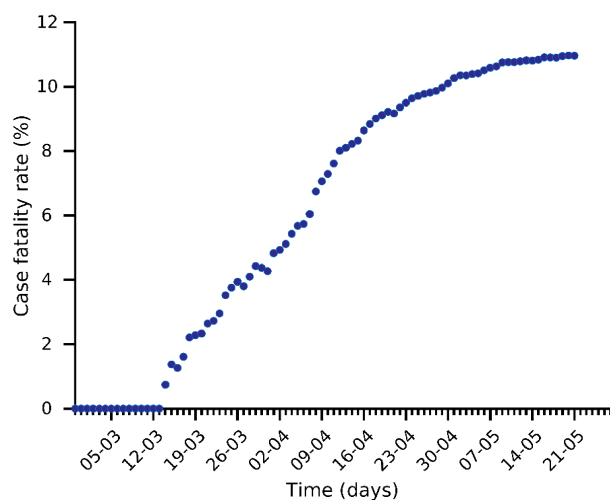
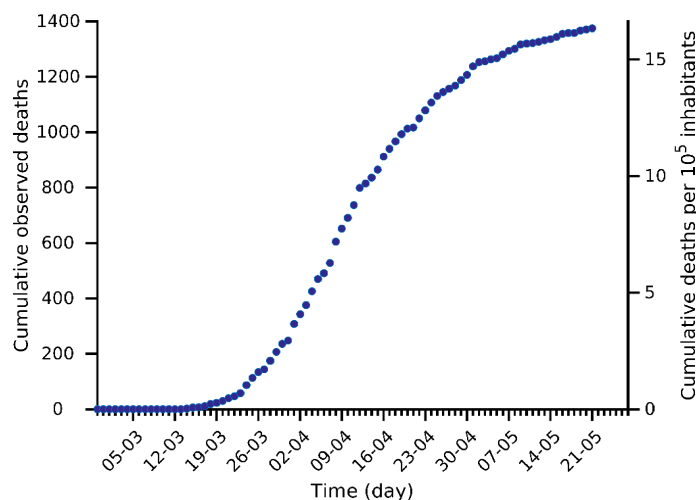
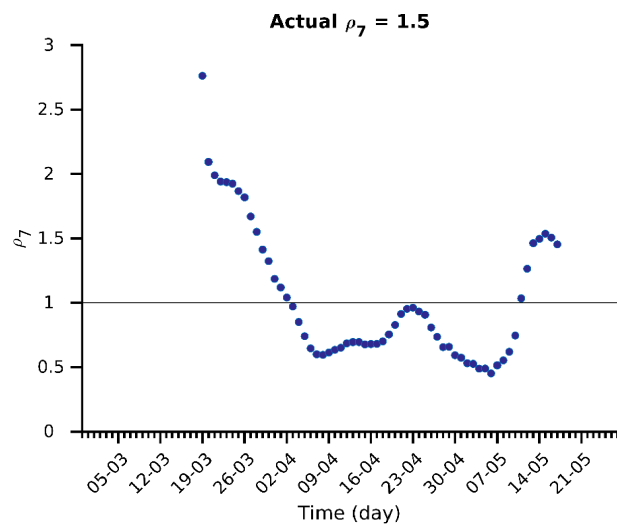
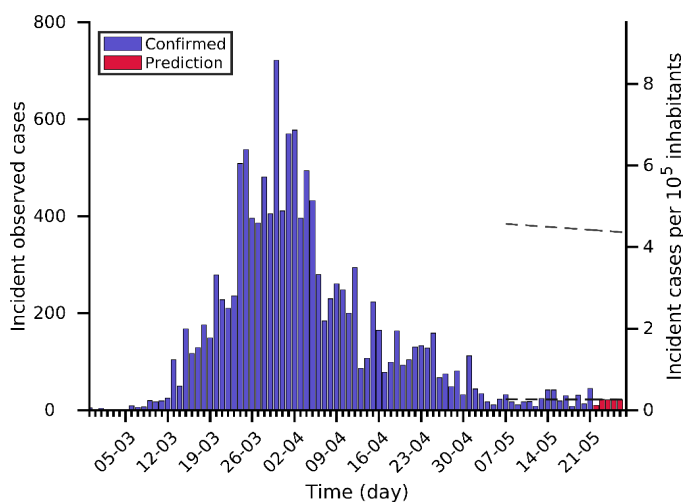
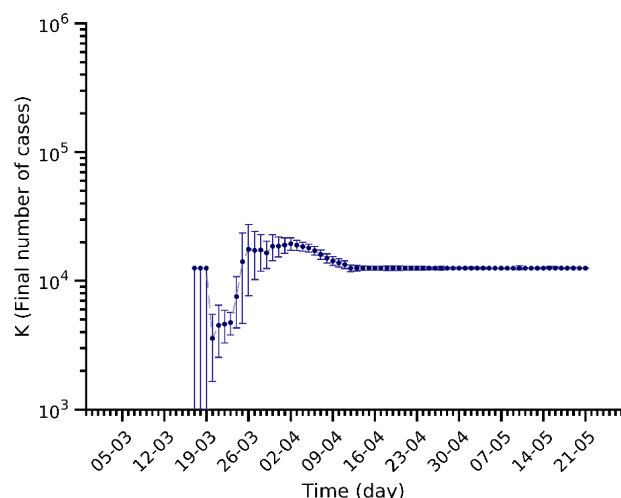
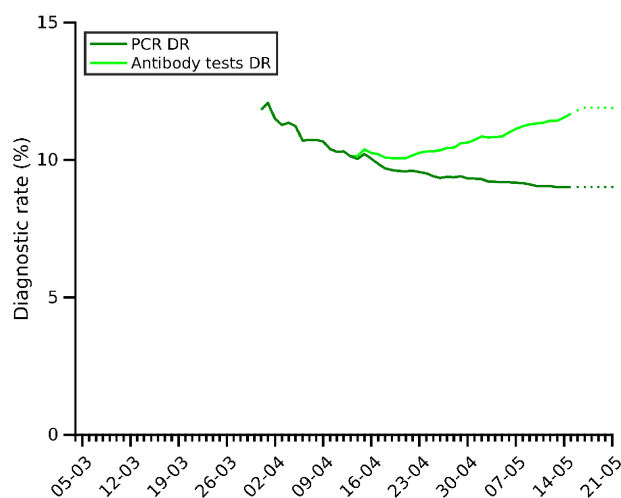
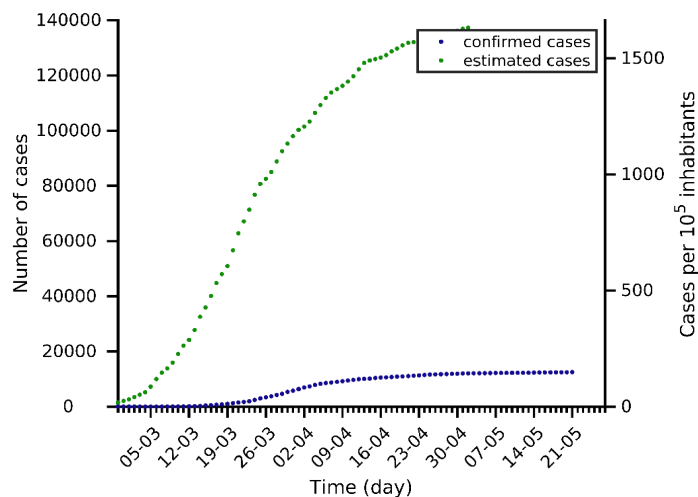
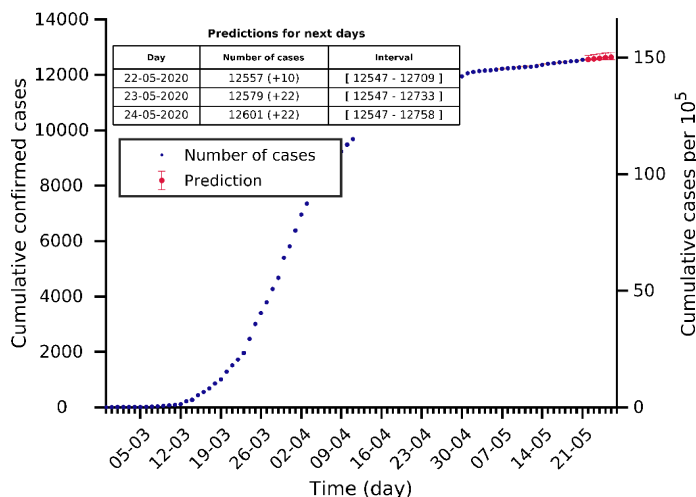
# Castilla-La Mancha 21-05-2020. Population: 2.0M. Current cumulated incidence: 82



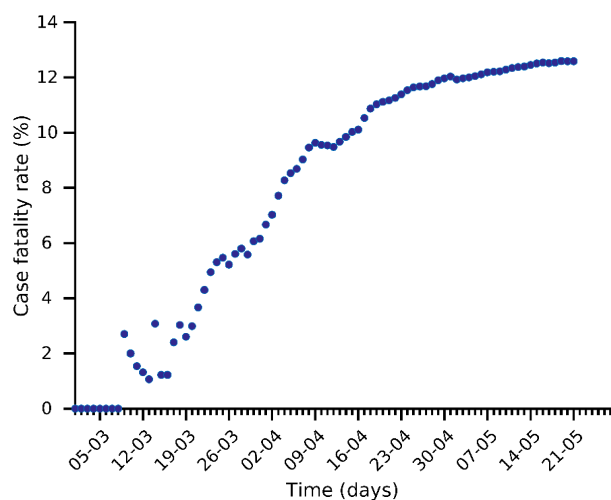
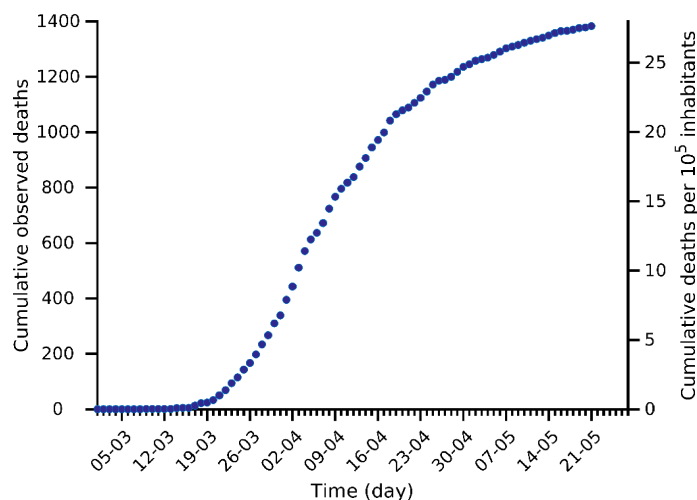
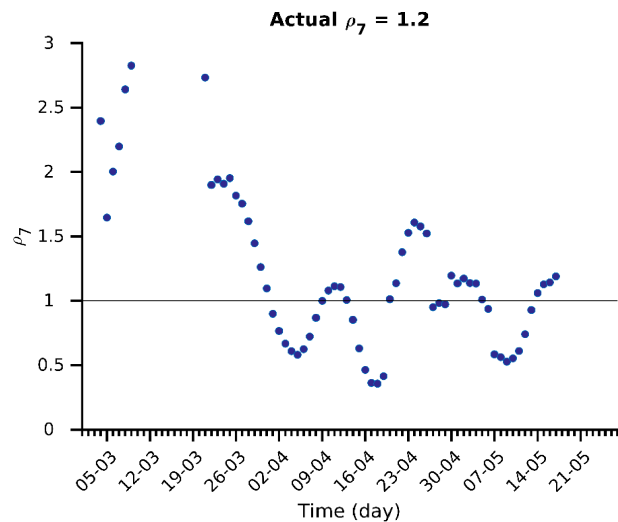
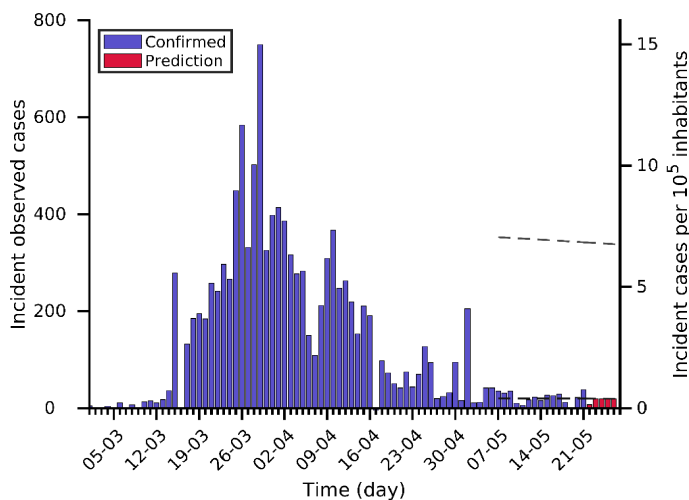
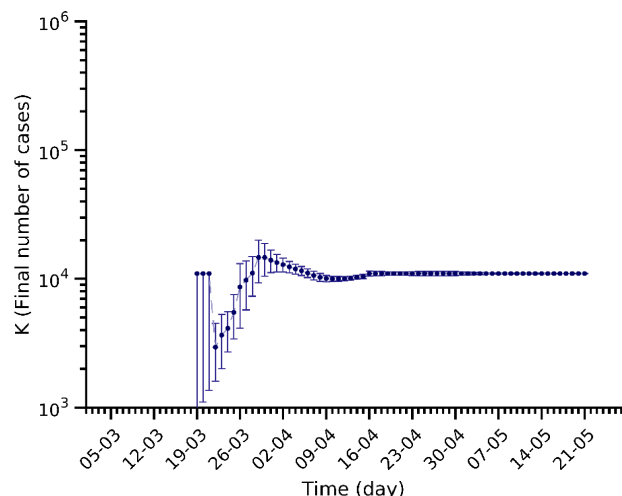
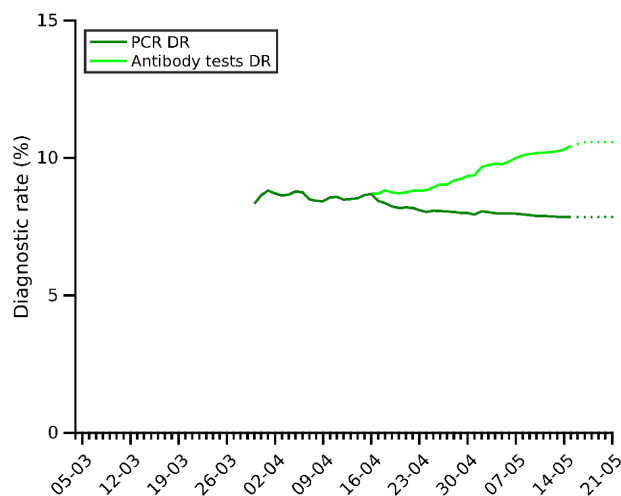
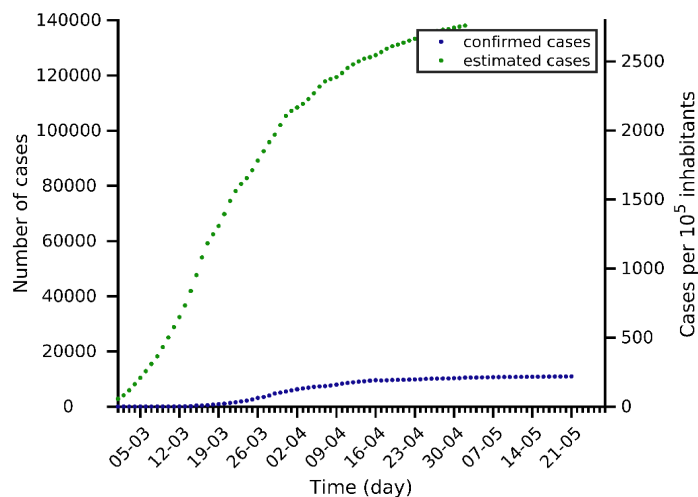
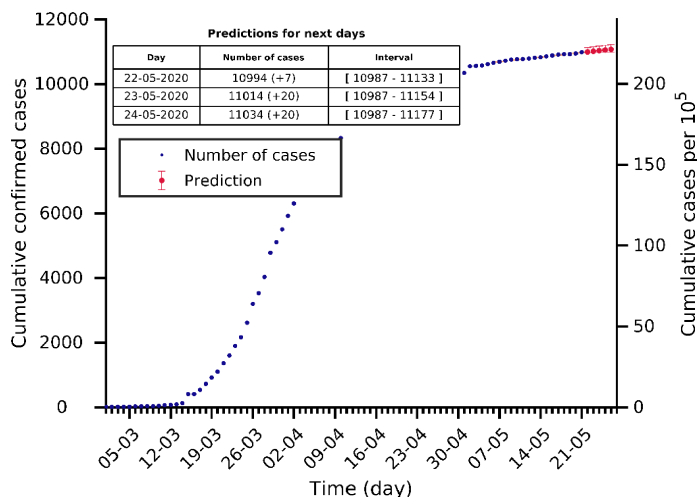
# Euskadi 21-05-2020. Population: 2.2M. Current cumulated incidence: 608/10<sup>5</sup>



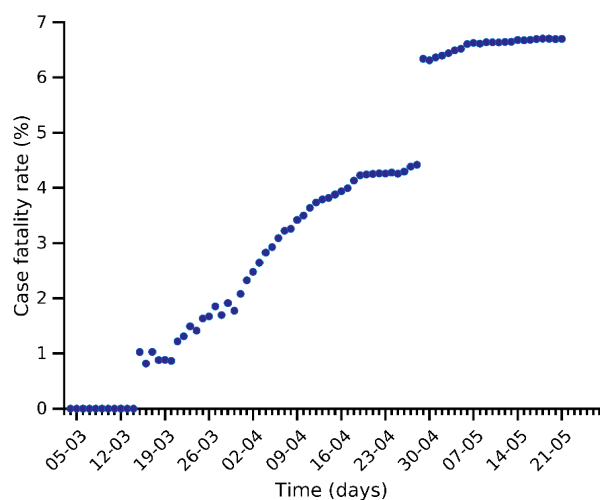
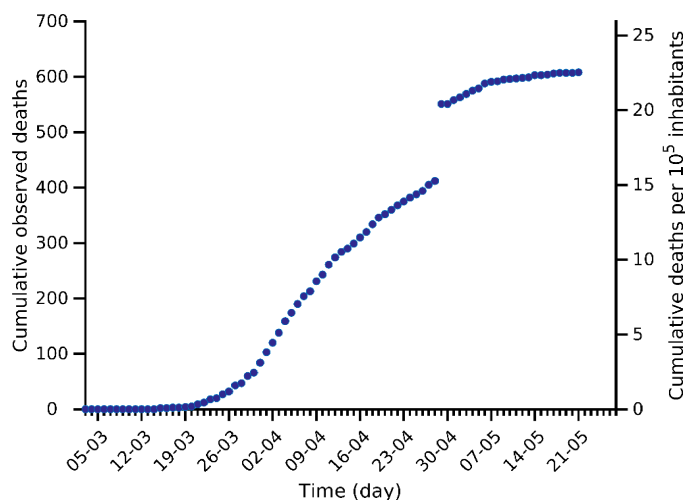
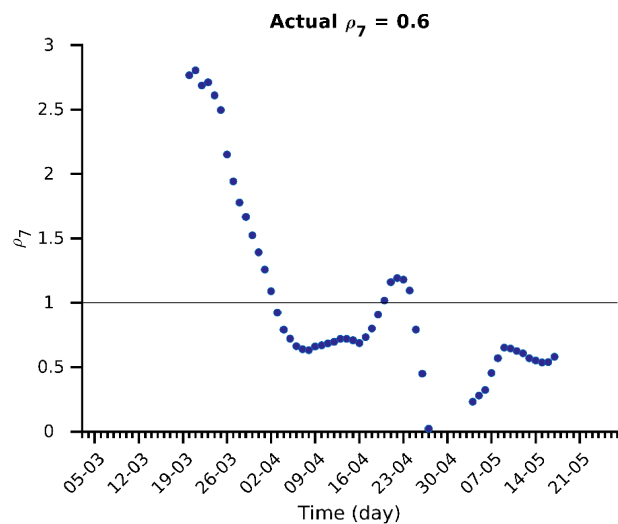
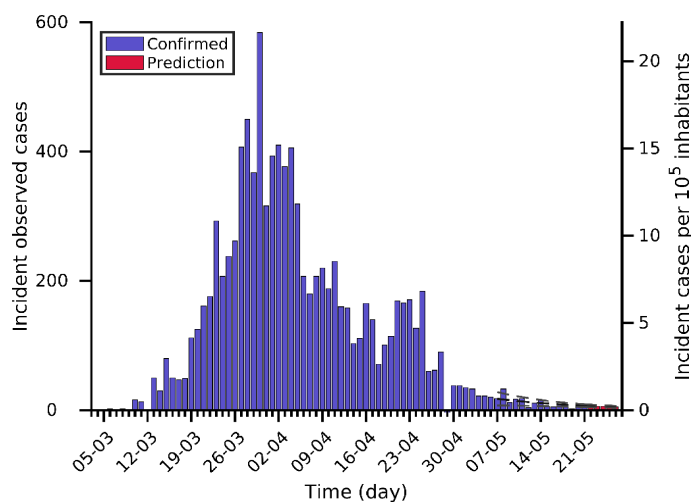
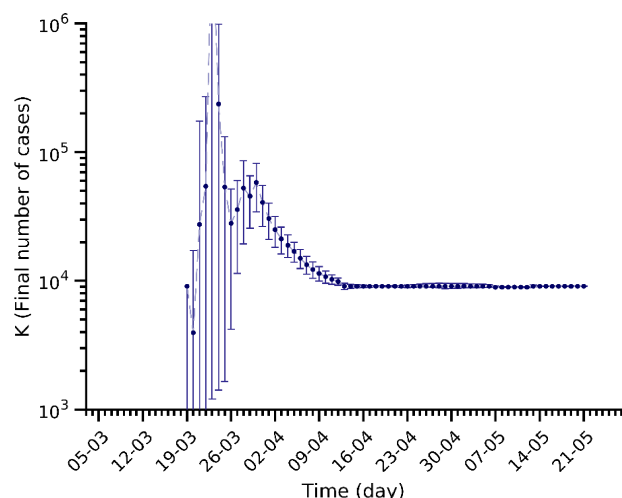
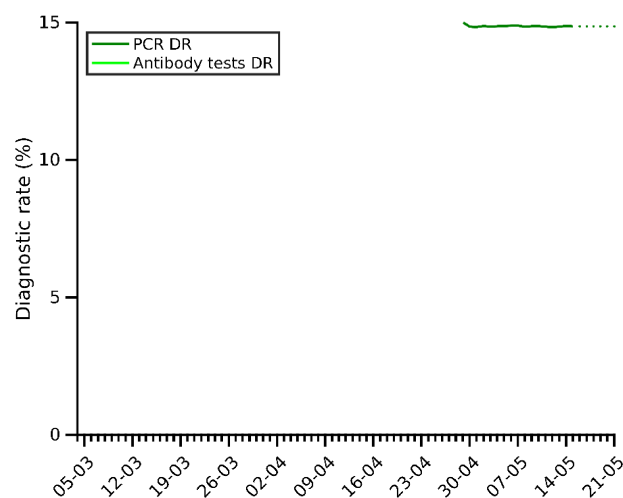
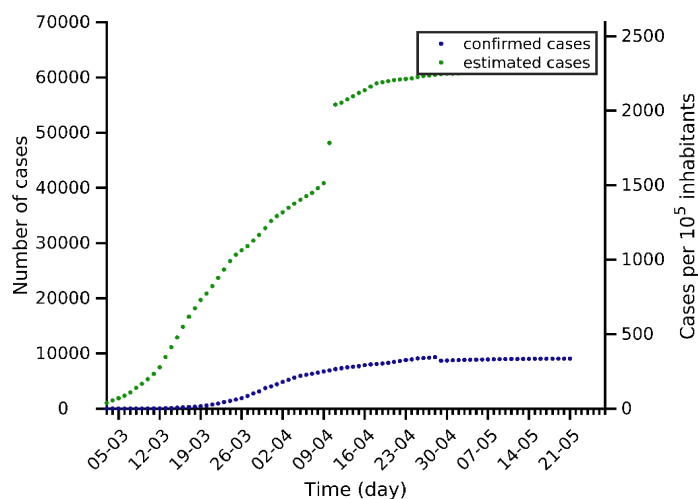
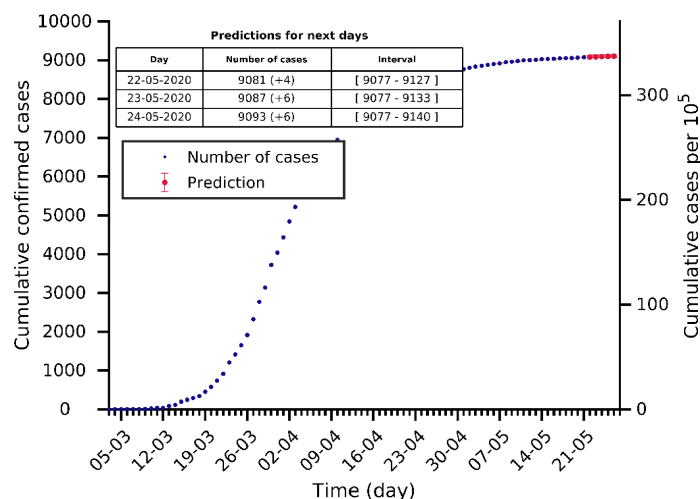
# Andalucia 21-05-2020. Population: 8.4M. Current cumulated incidence: 149/10<sup>5</sup>



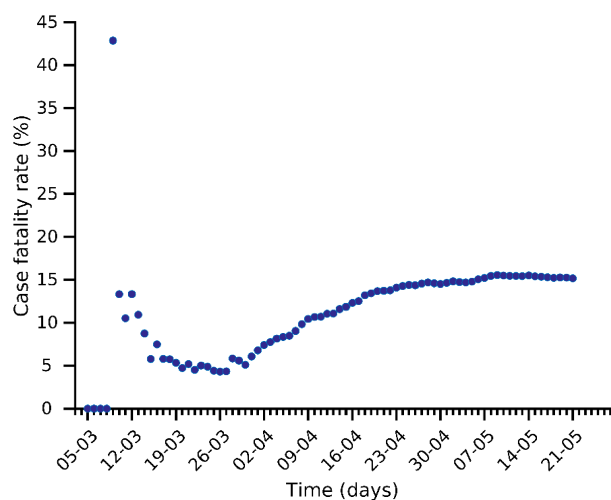
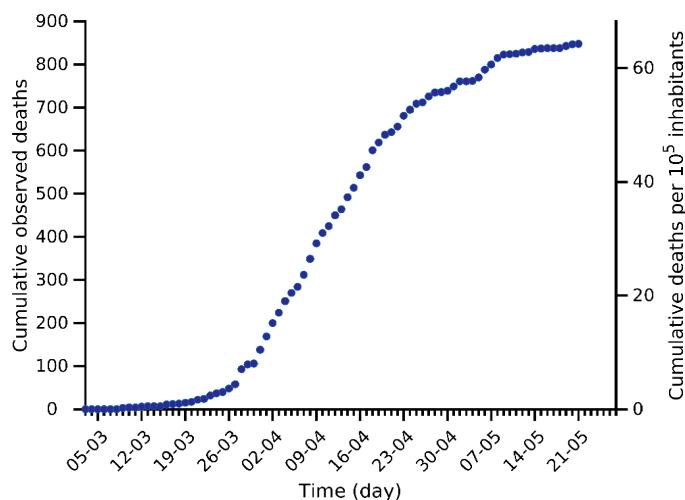
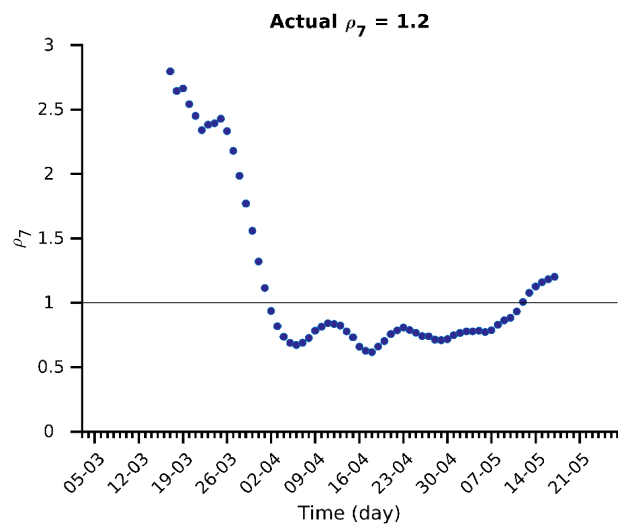
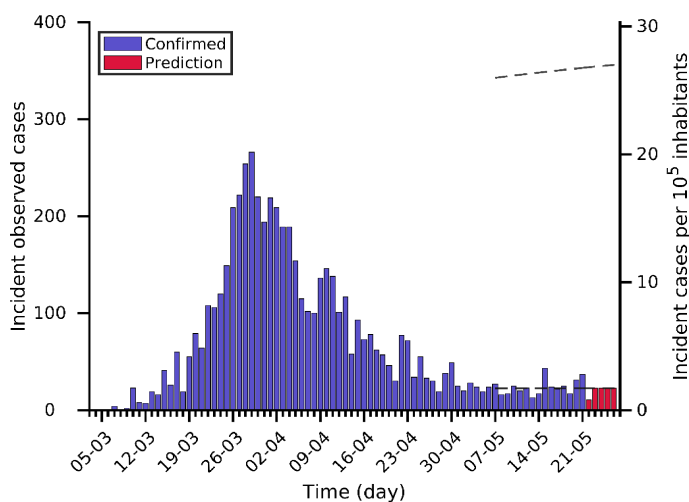
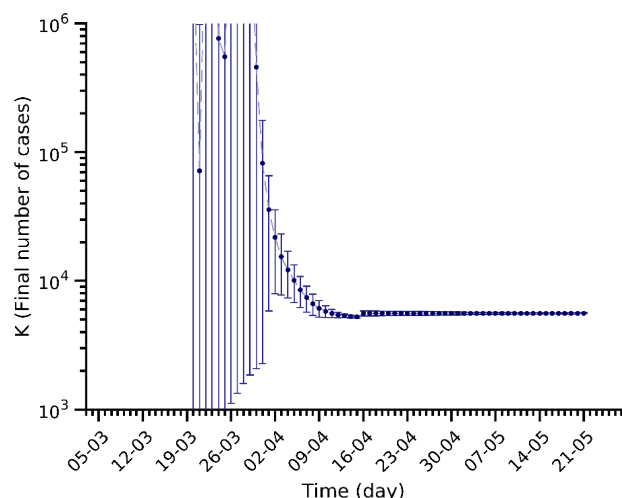
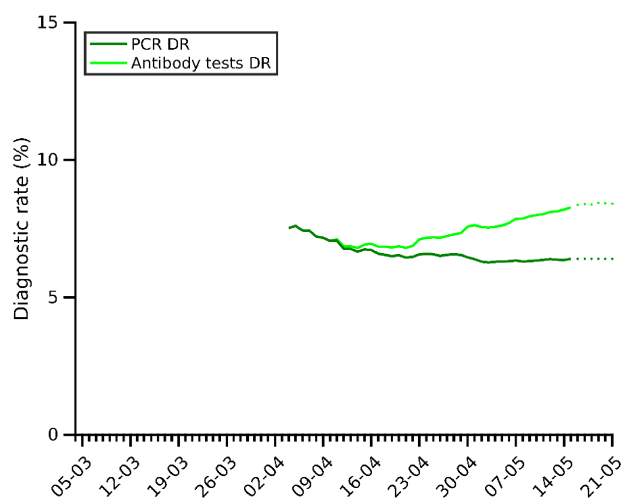
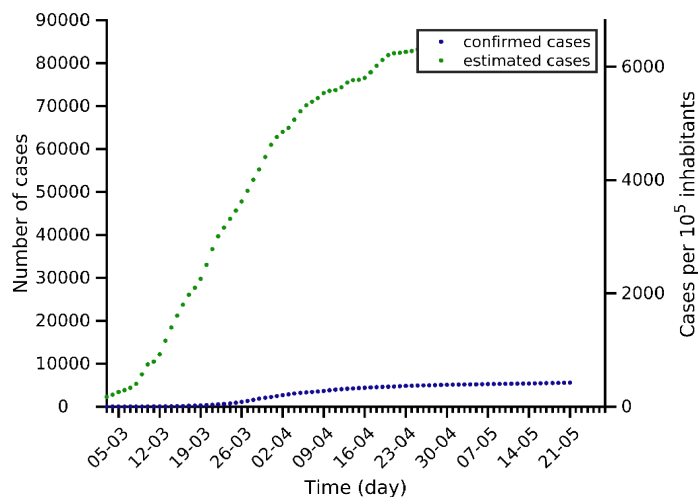
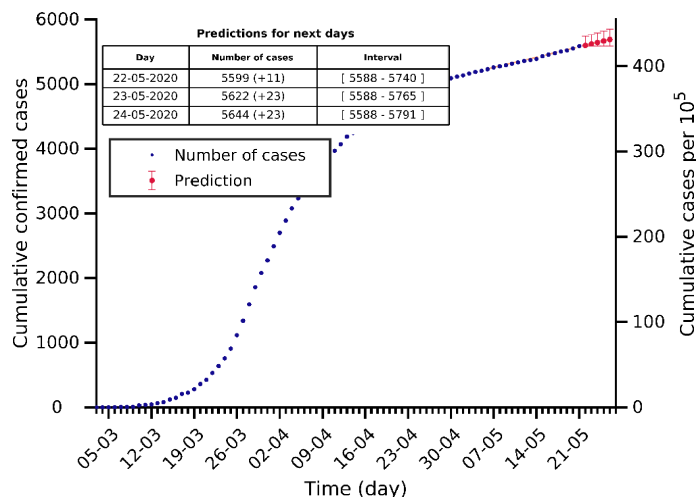
# C Valenciana 21-05-2020. Population: 5.0M. Current cumulated incidence: 220/10<sup>5</sup>



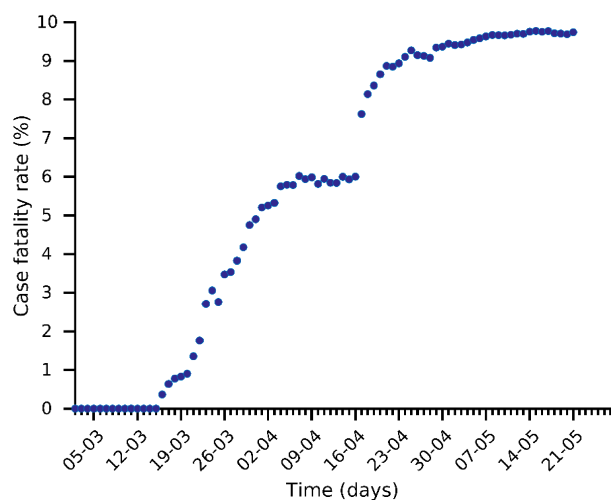
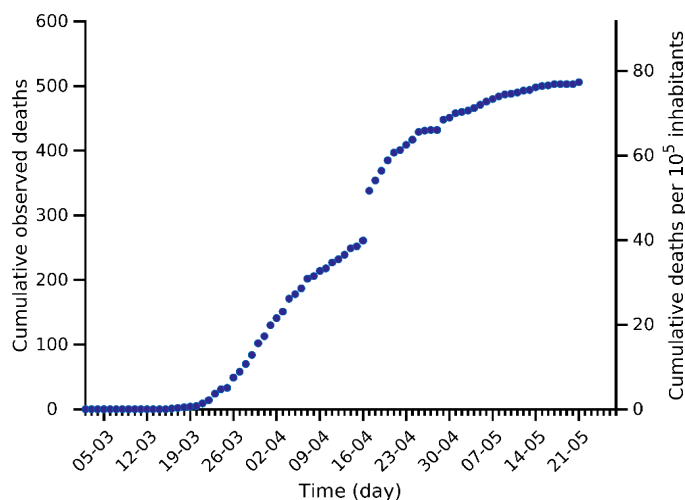
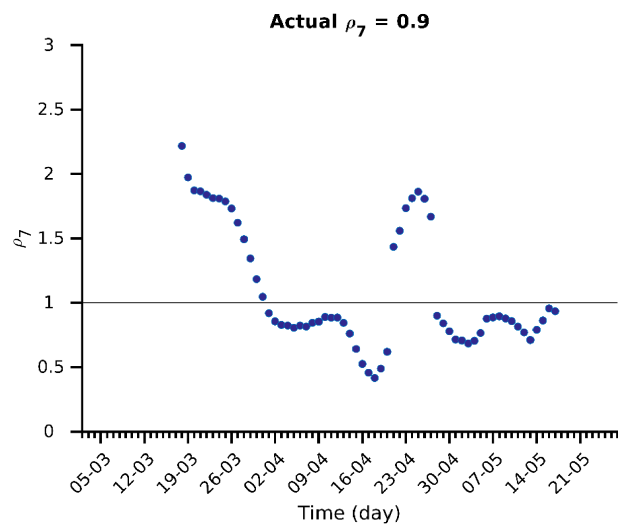
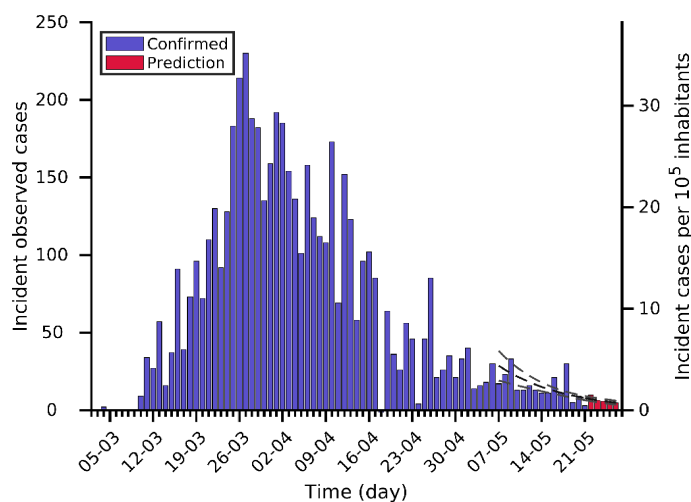
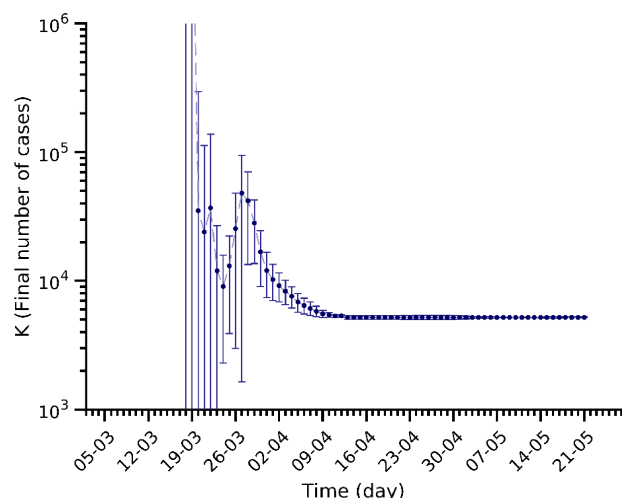
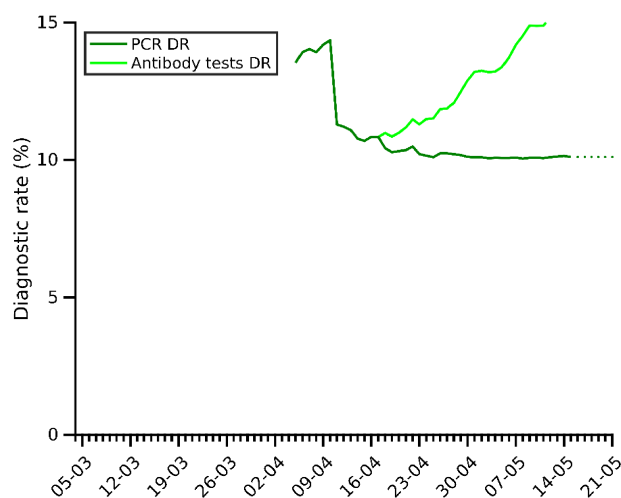
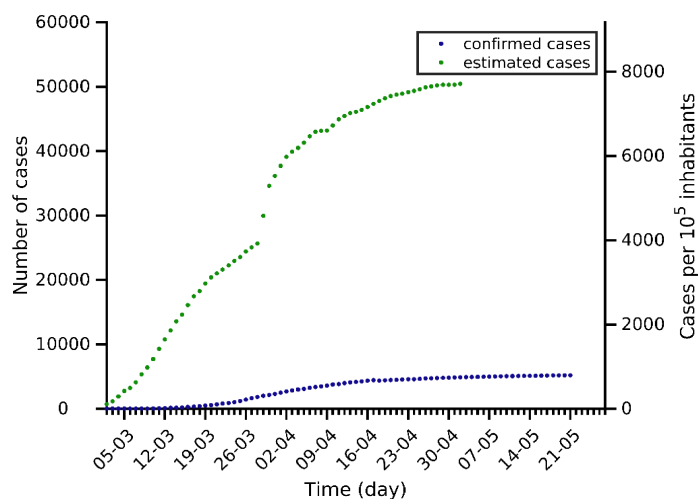
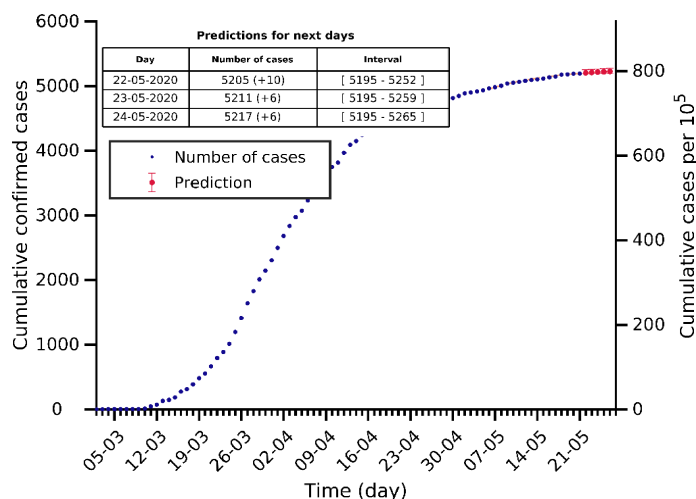
# Galicia 21-05-2020. Population: 2.7M. Current cumulated incidence: 336/10<sup>5</sup>



# Aragon 21-05-2020. Population: 1.3M. Current cumulated incidence: 424/10<sup>5</sup>

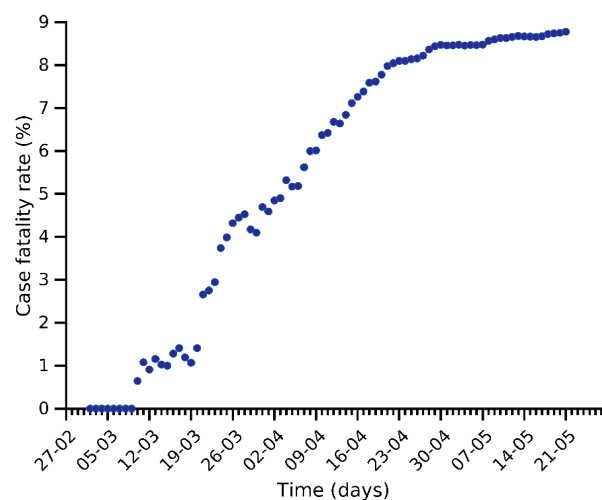
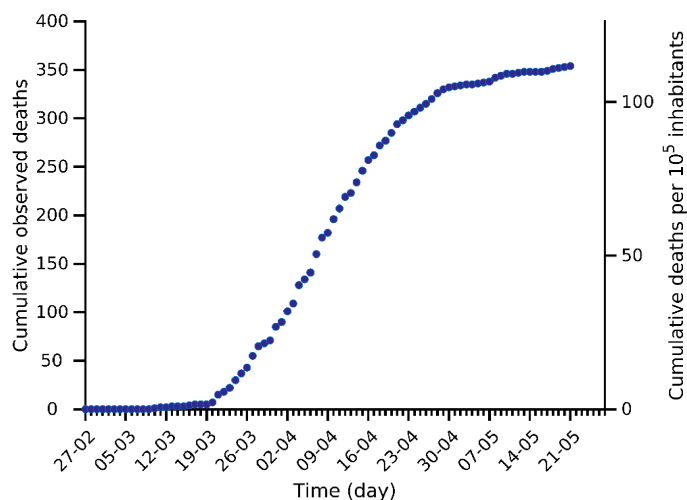
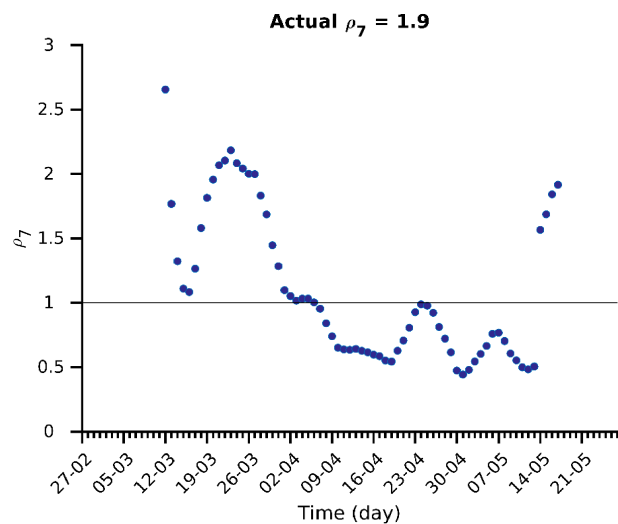
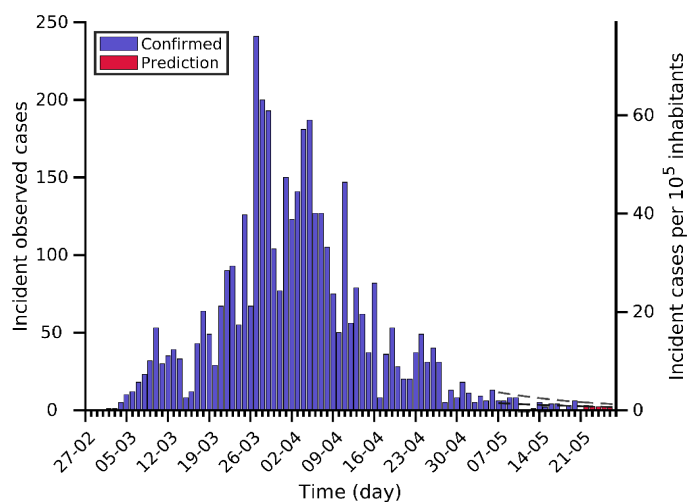
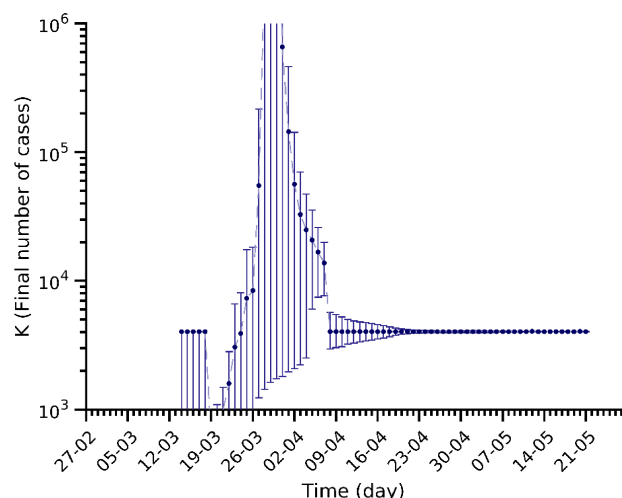
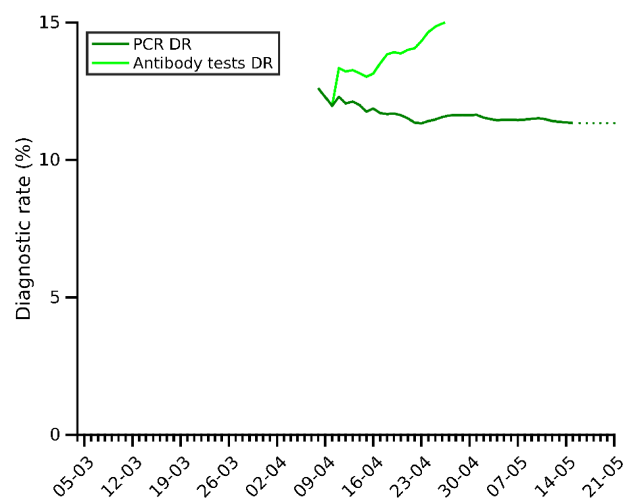
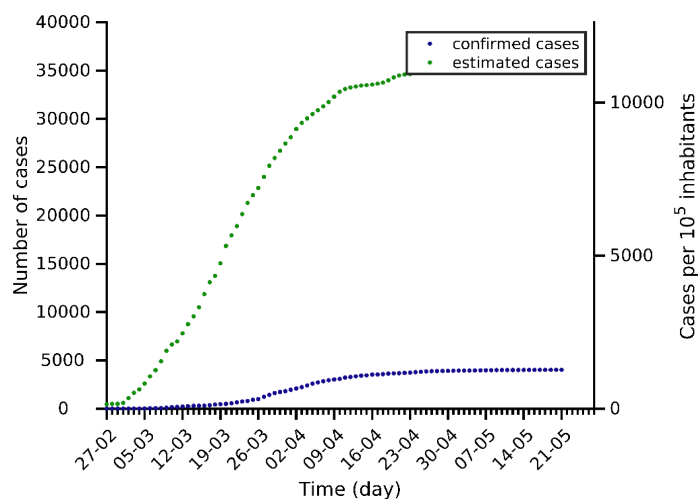
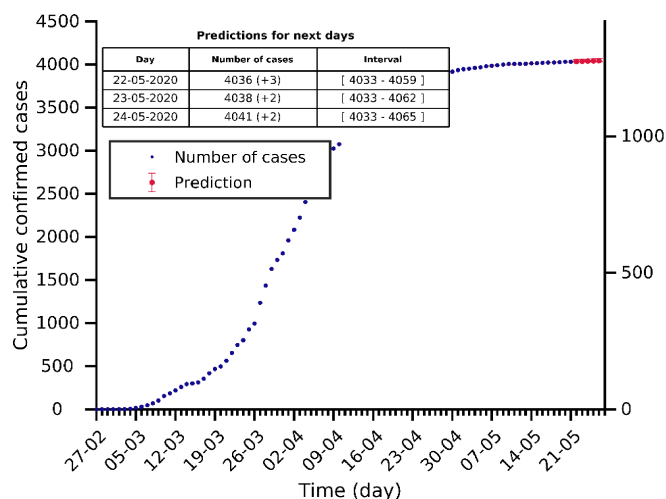


# Navarra 21-05-2020. Population: 0.7M. Current cumulated incidence: 794/10<sup>5</sup>

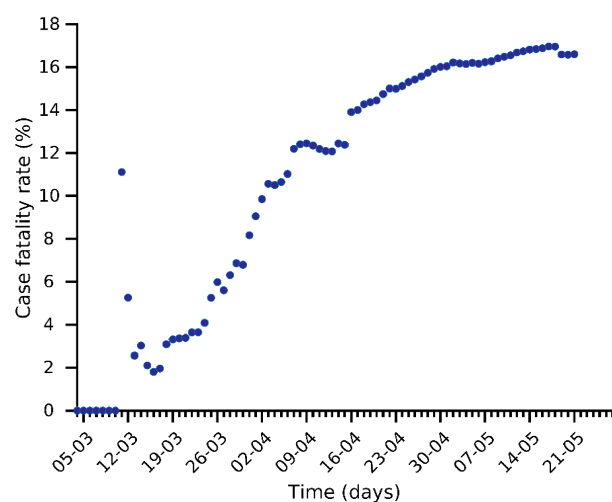
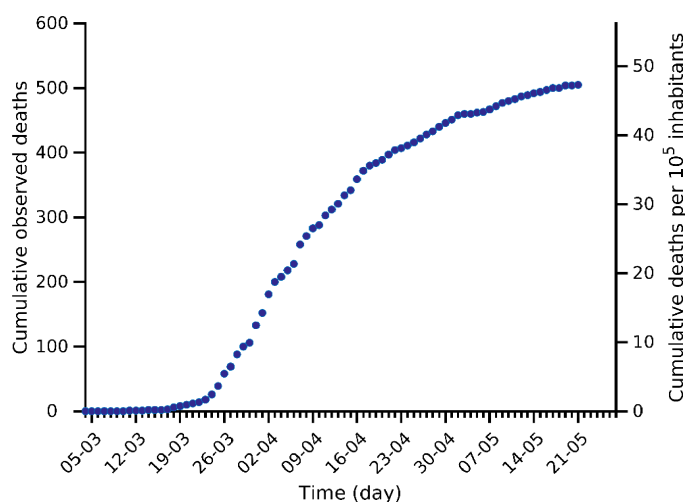
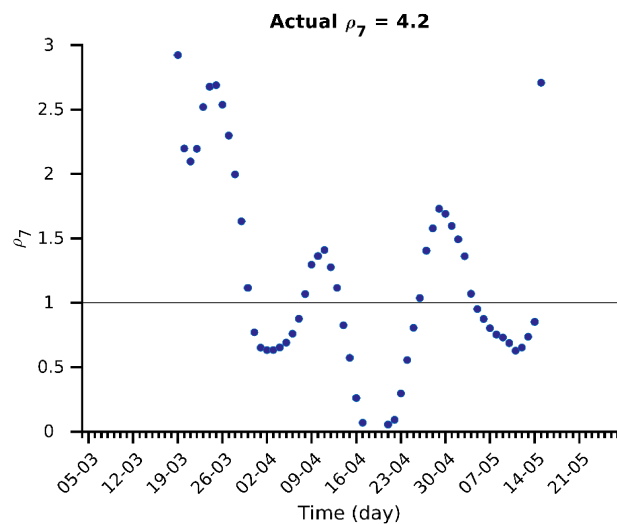
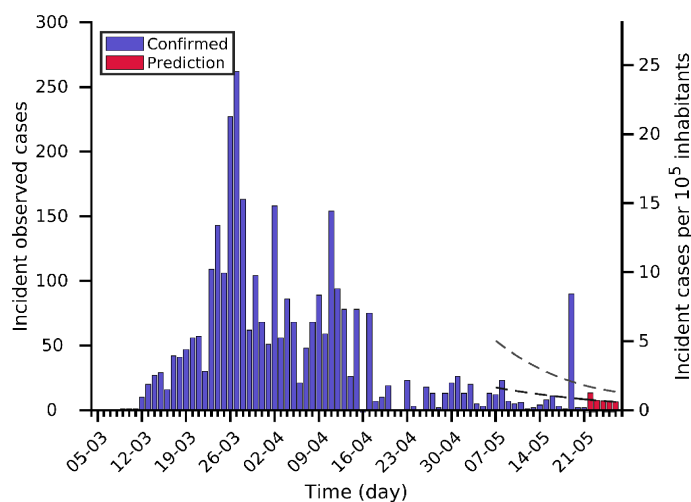
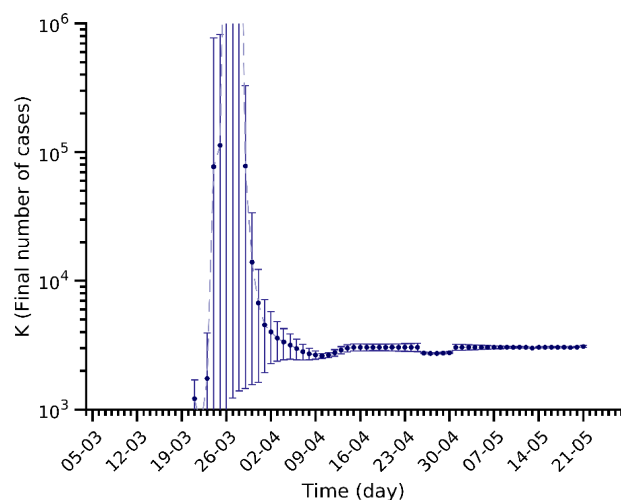
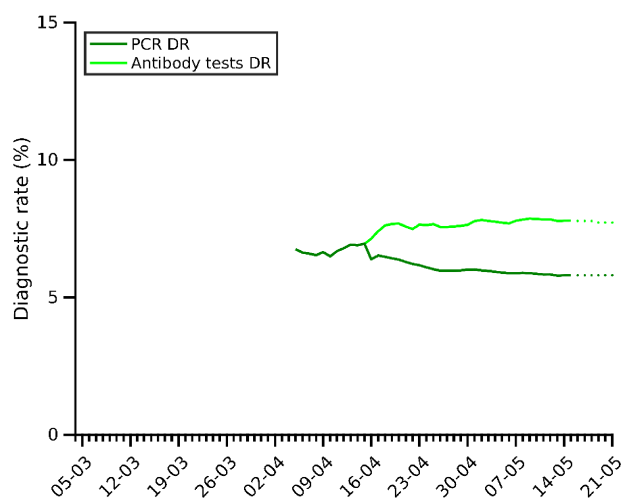
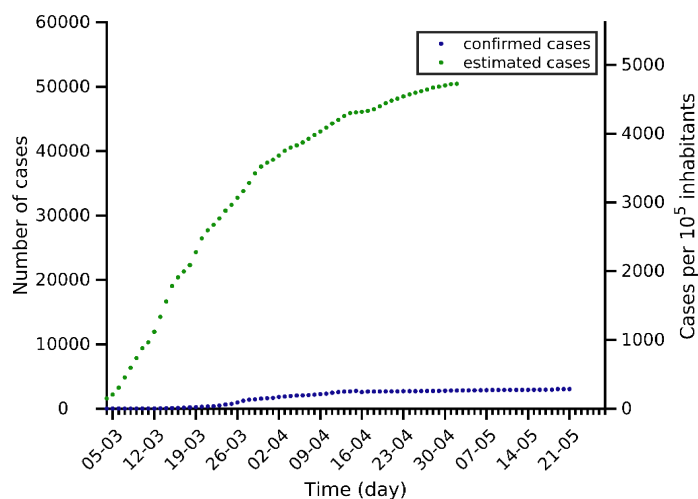
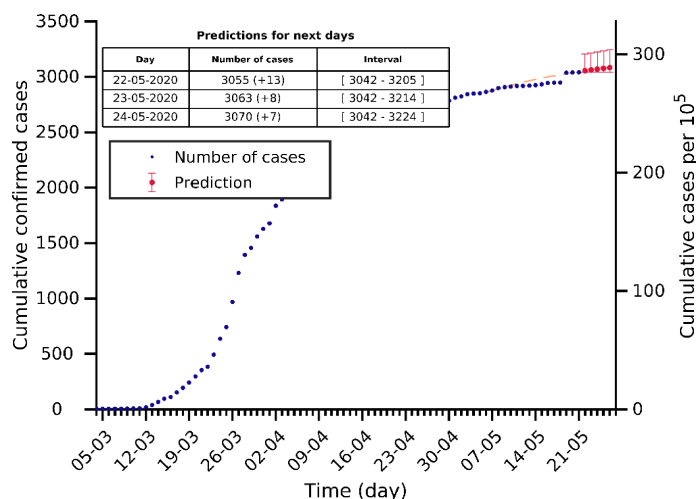




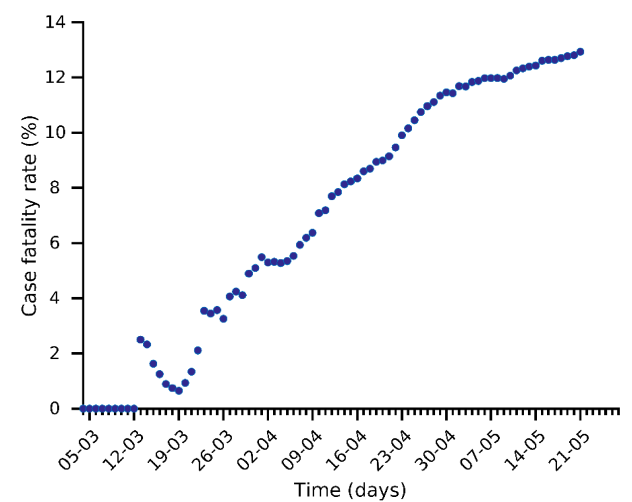
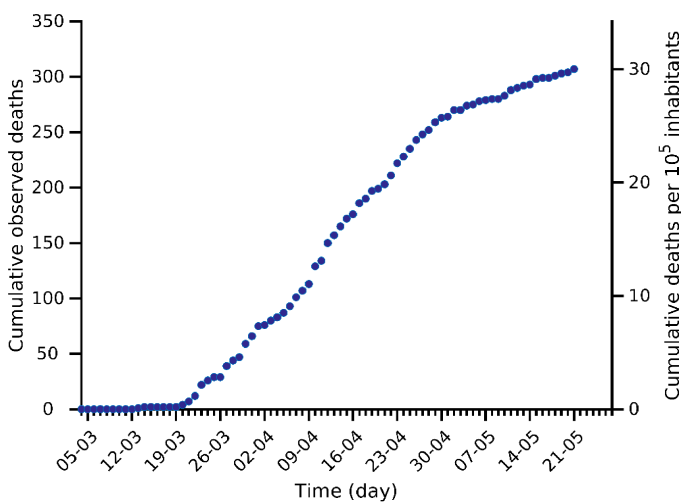
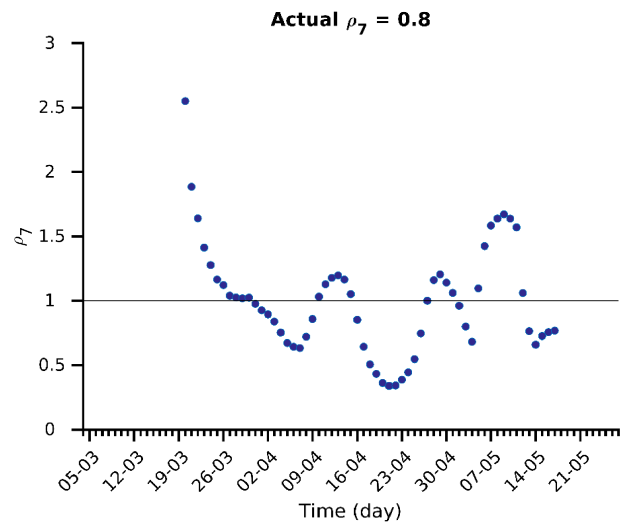
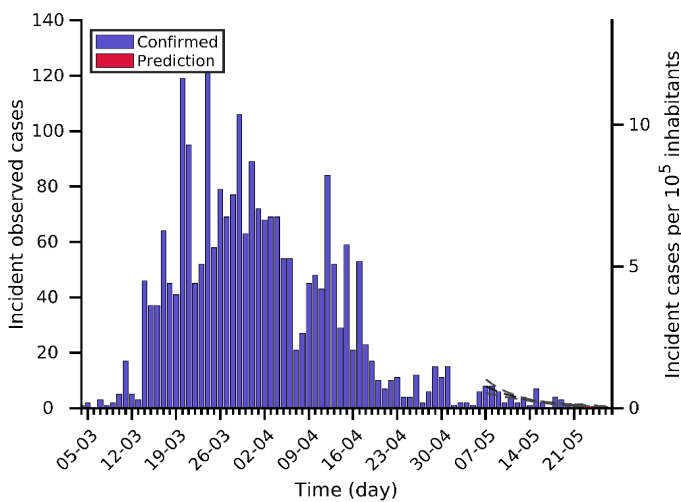
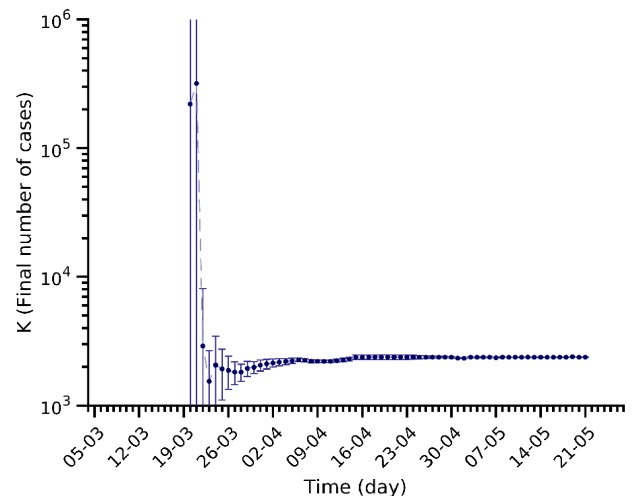
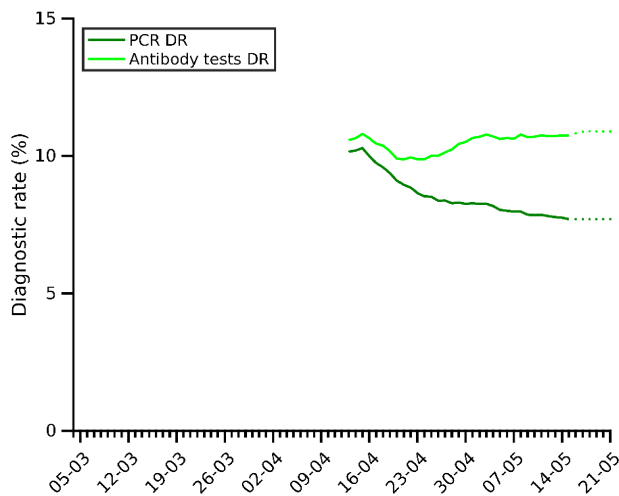
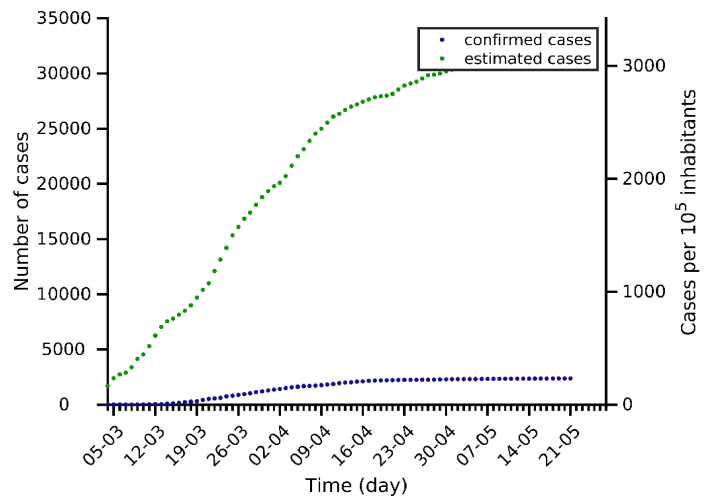
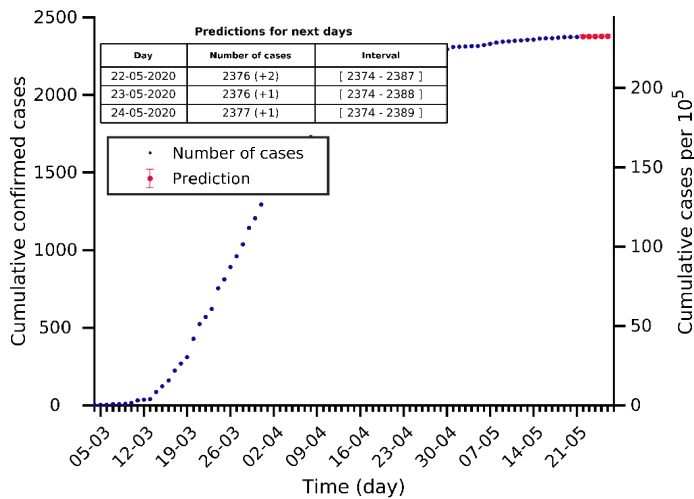
# La Rioja 21-05-2020. Population: 0.3M. Current cumulated incidence: 1273/10<sup>5</sup>



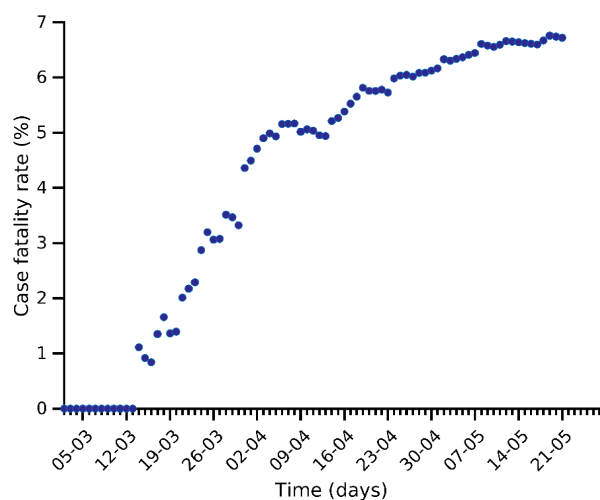
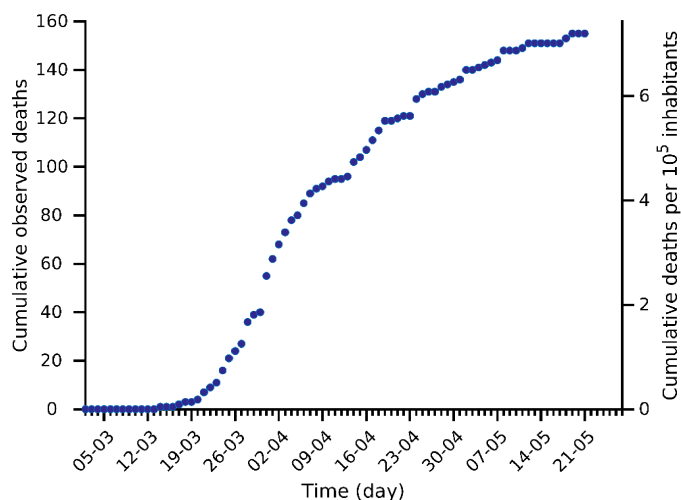
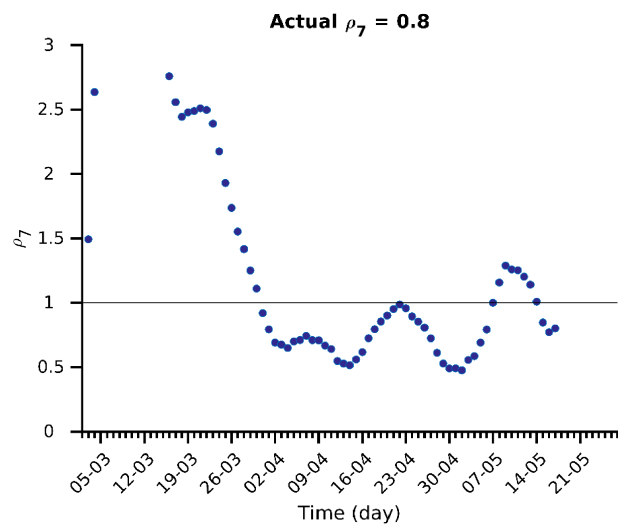
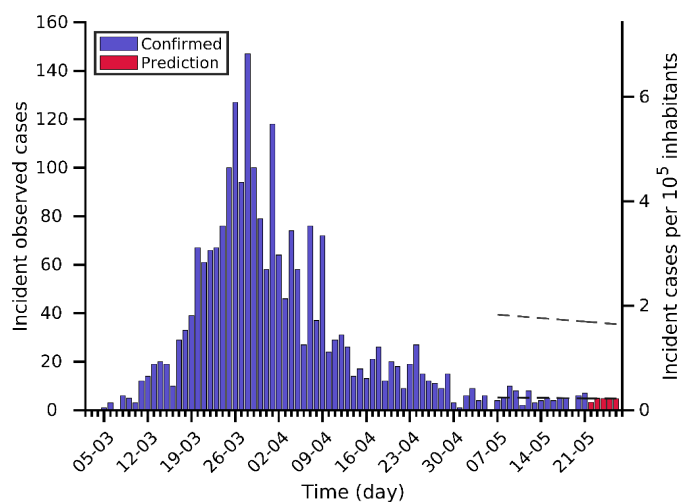
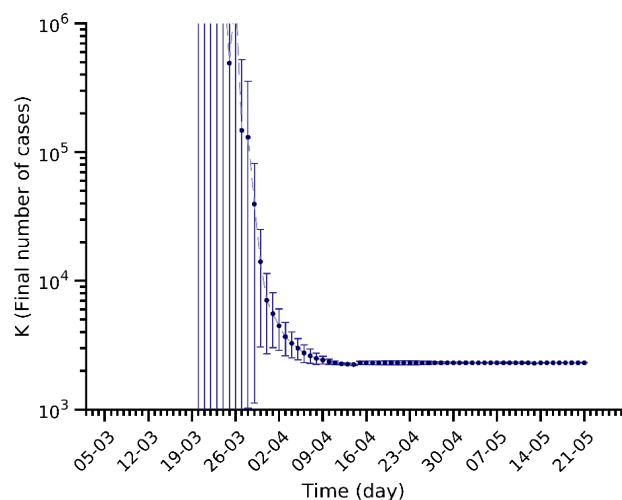
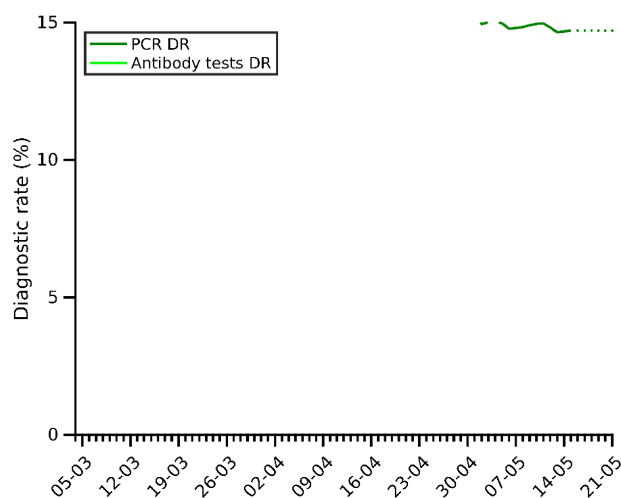
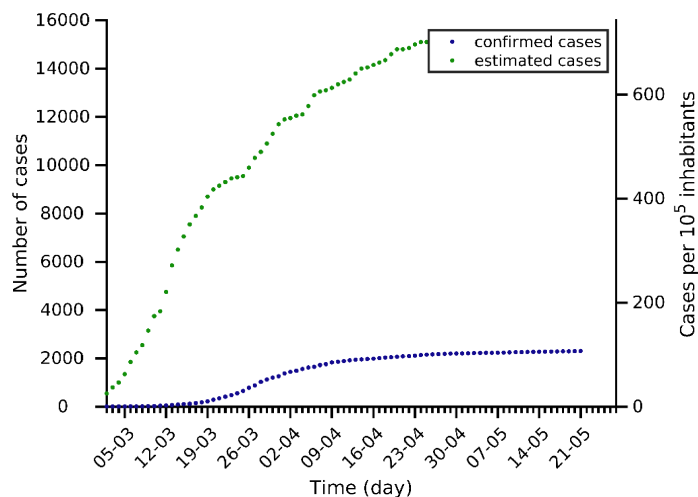
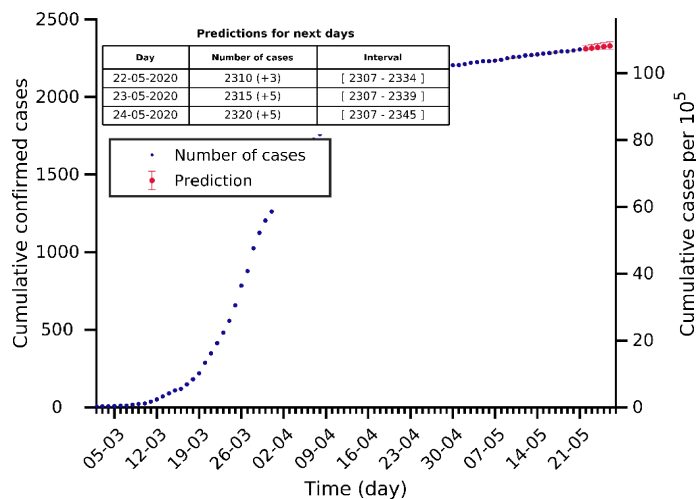
# Extremadura 21-05-2020. Population: 1.1M. Current cumulated incidence: 285/10<sup>5</sup>



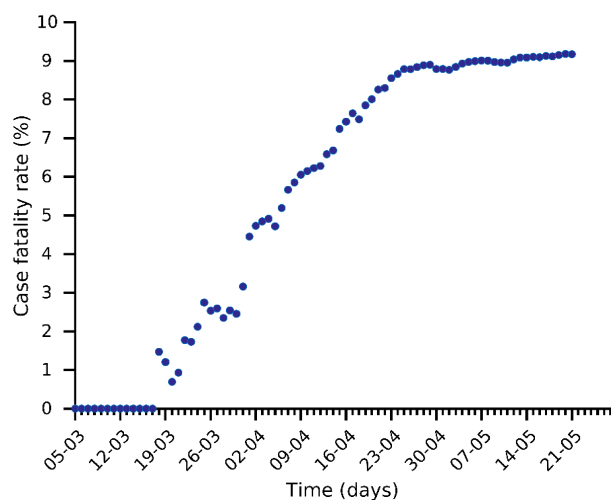
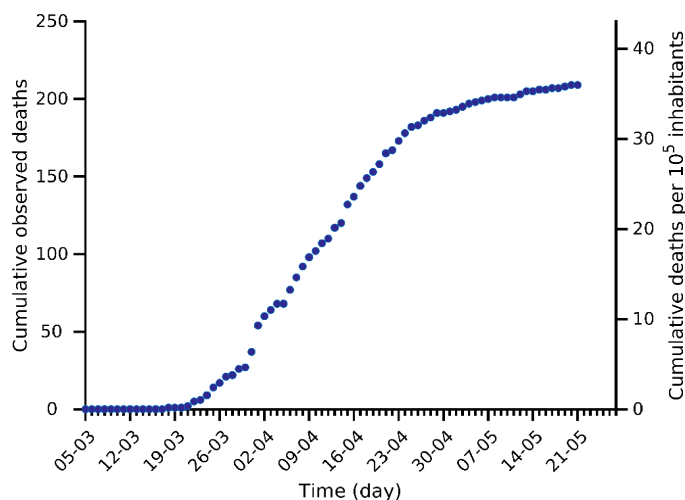
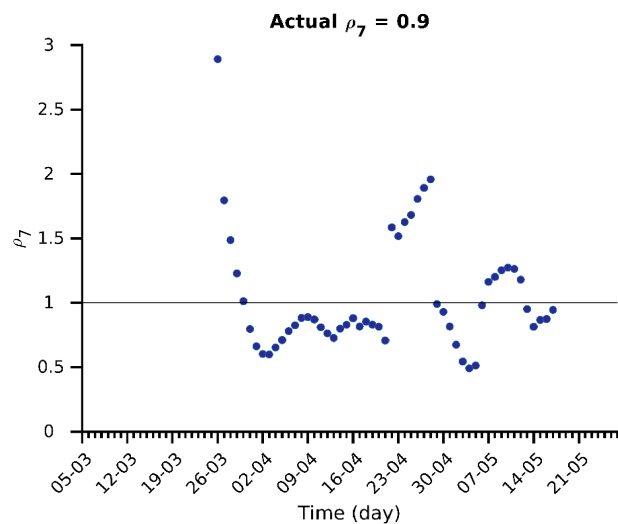
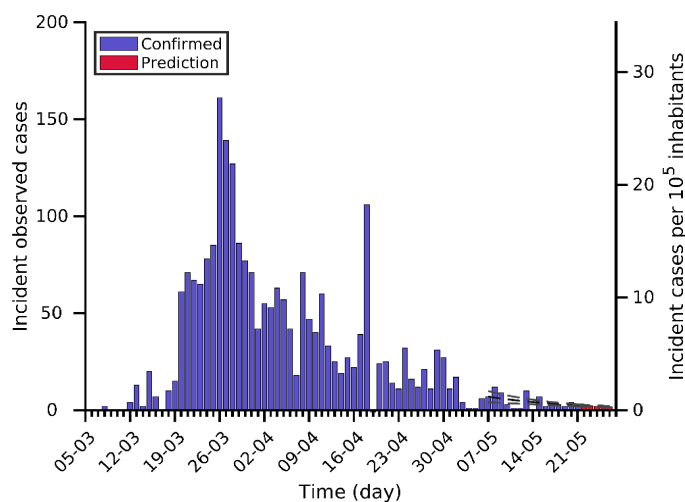
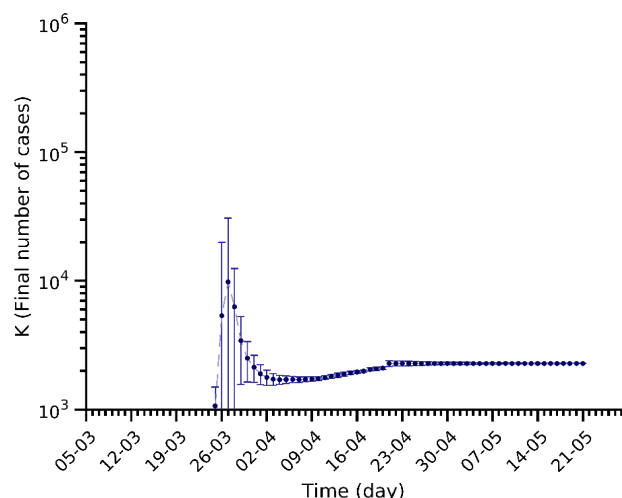
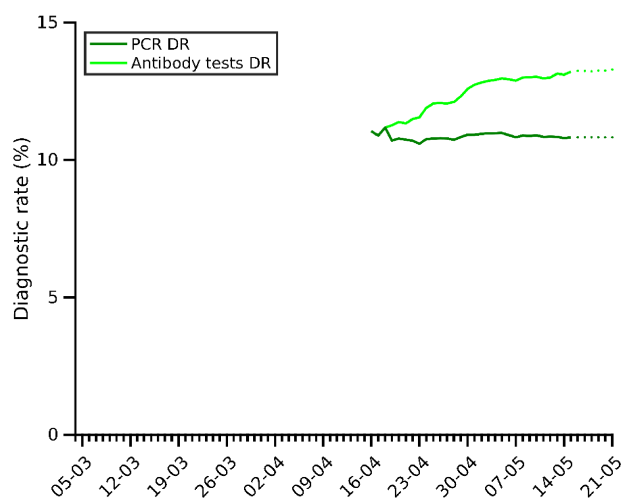
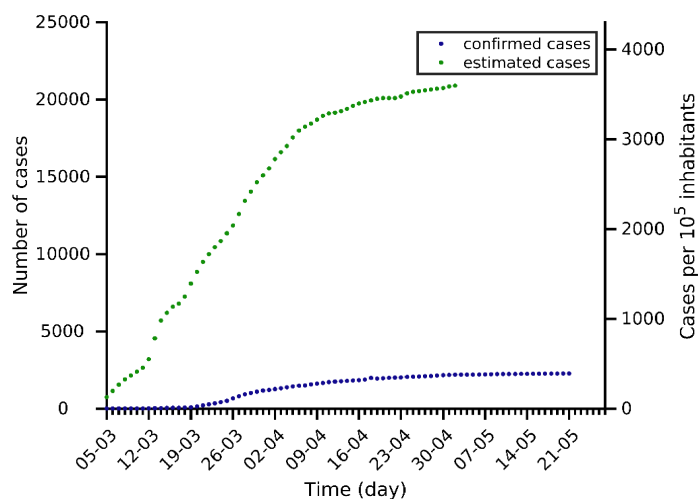
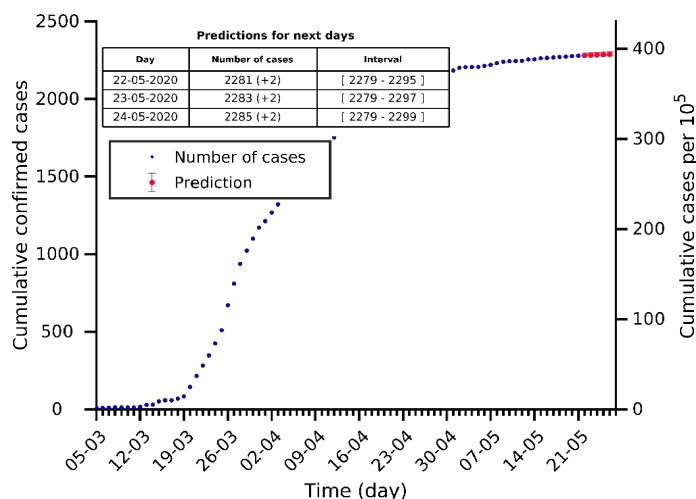
# Asturias 21-05-2020. Population: 1.0M. Current cumulated incidence: 232/10<sup>5</sup>



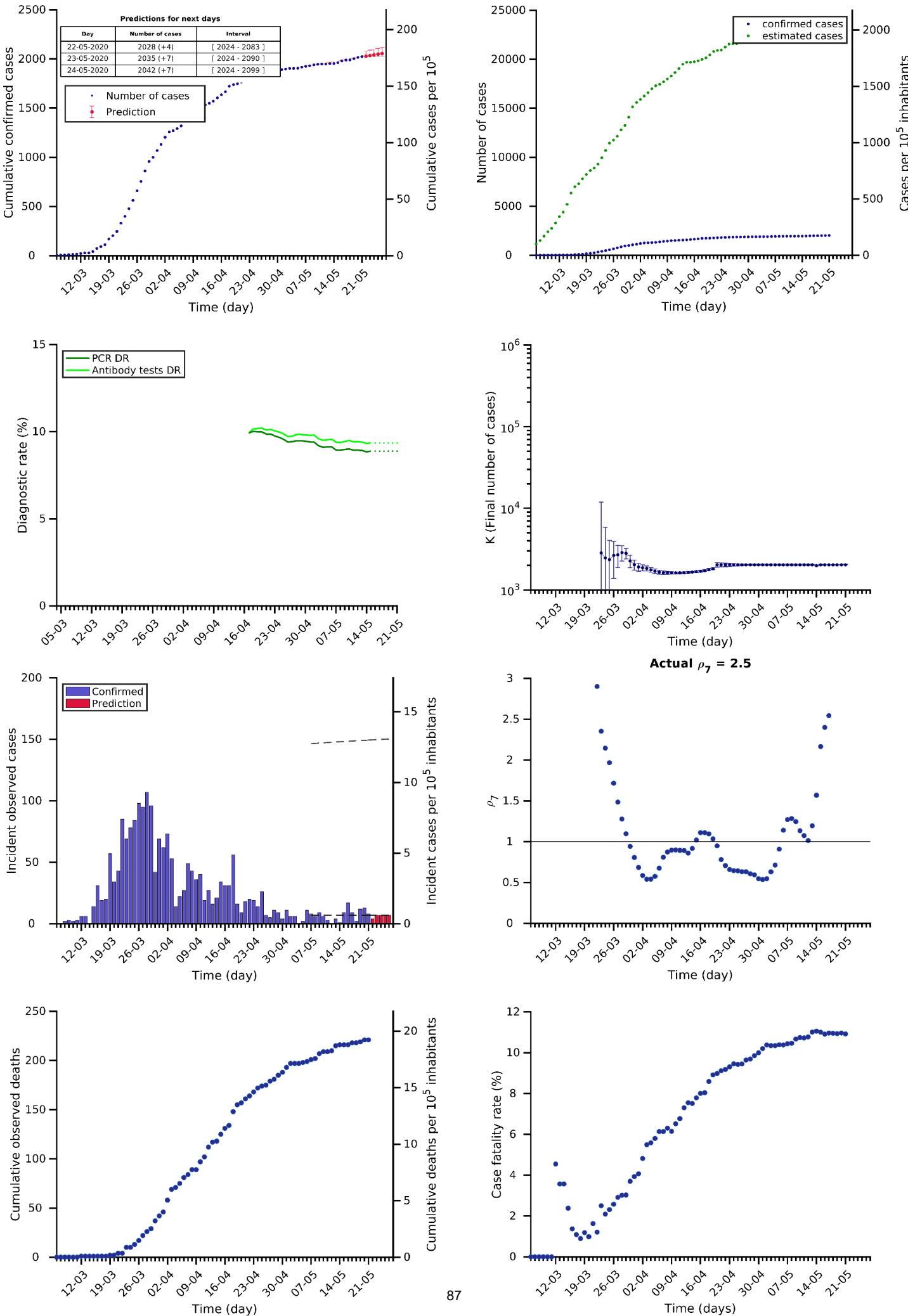
# Canarias 21-05-2020. Population: 2.2M. Current cumulated incidence: 107/10<sup>5</sup>



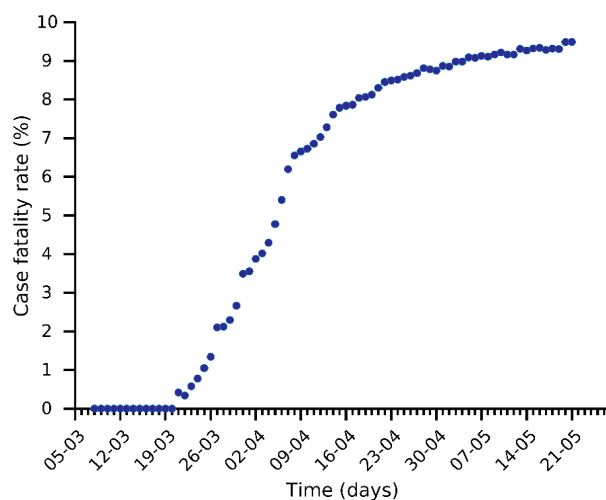
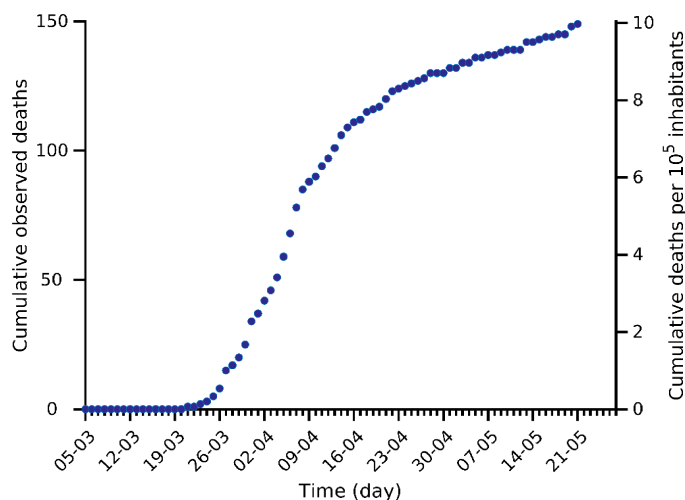
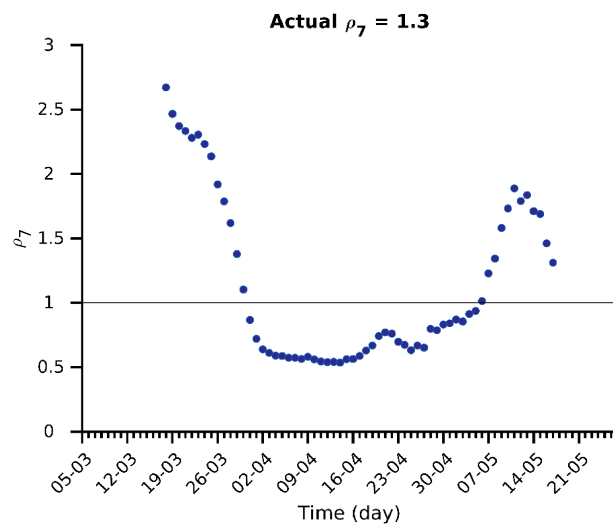
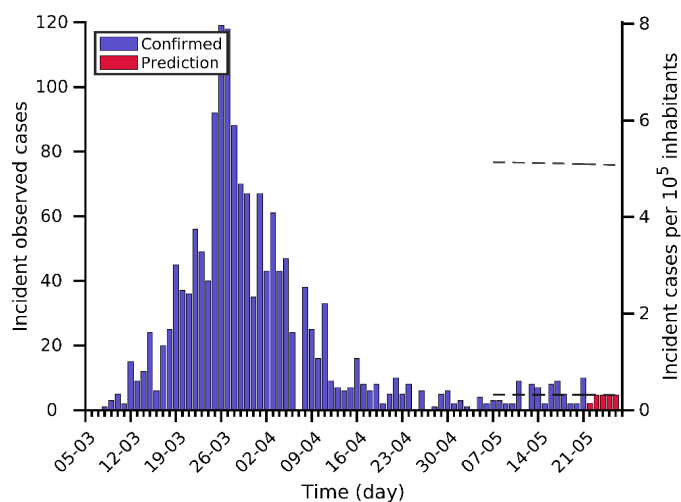
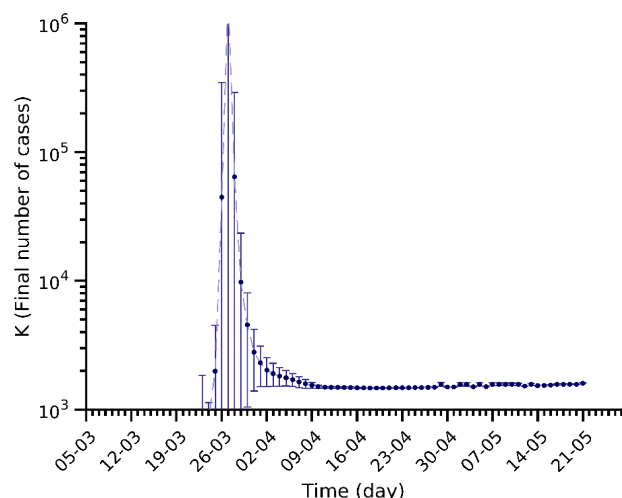
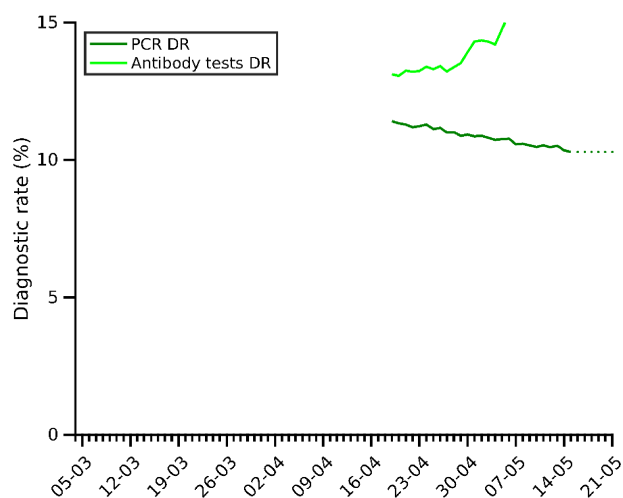
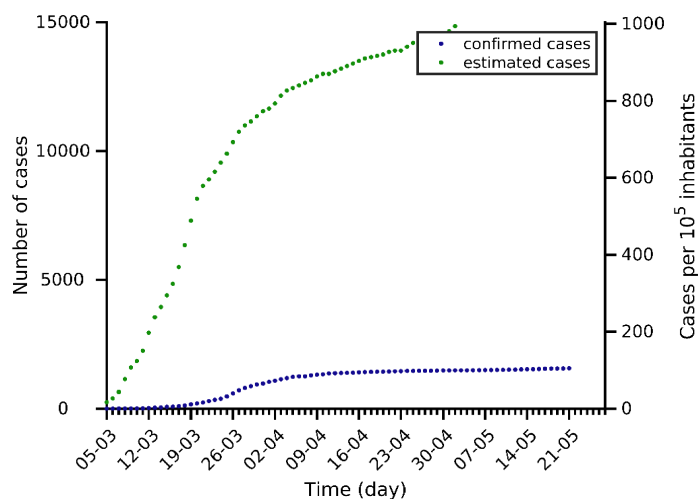
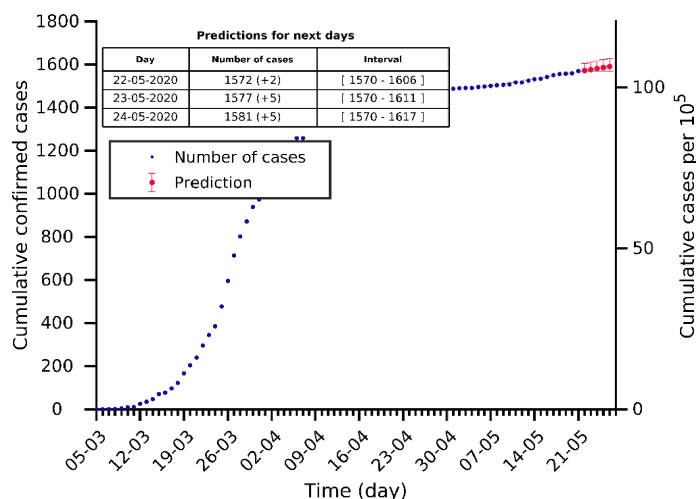
# Cantabria 21-05-2020. Population: 0.6M. Current cumulated incidence: 392/10<sup>5</sup>



Baleares 21-05-2020. Population: 1.1M. Current cumulated incidence: 176/10<sup>5</sup>



# Murcia 21-05-2020. Population: 1.5M. Current cumulated incidence: 105/10<sup>5</sup>

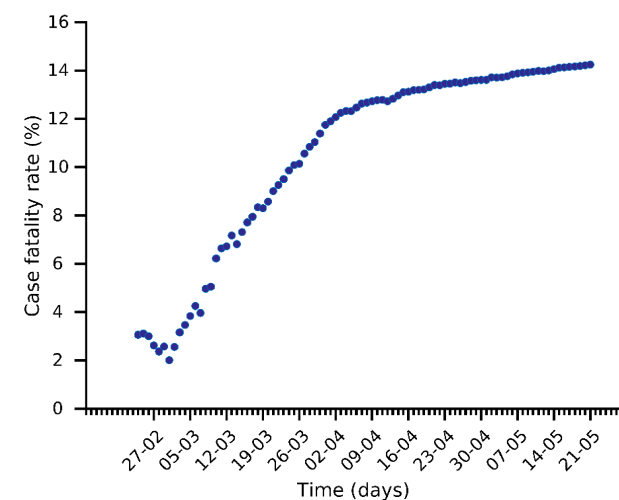
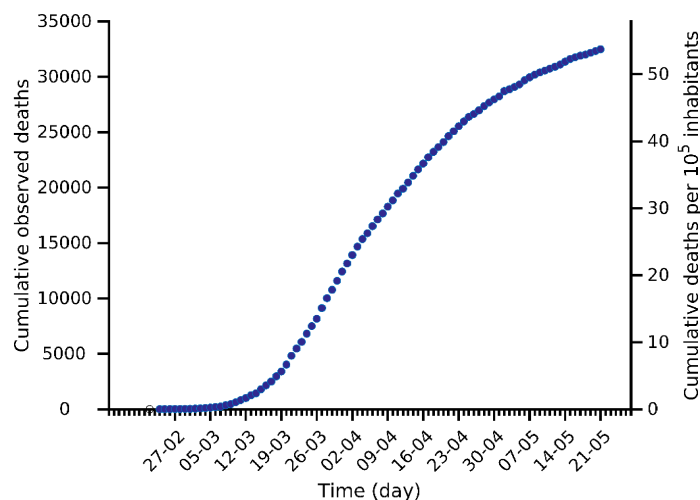
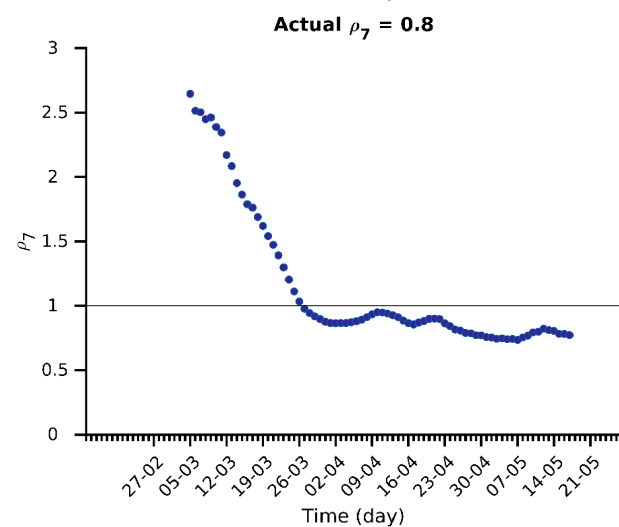
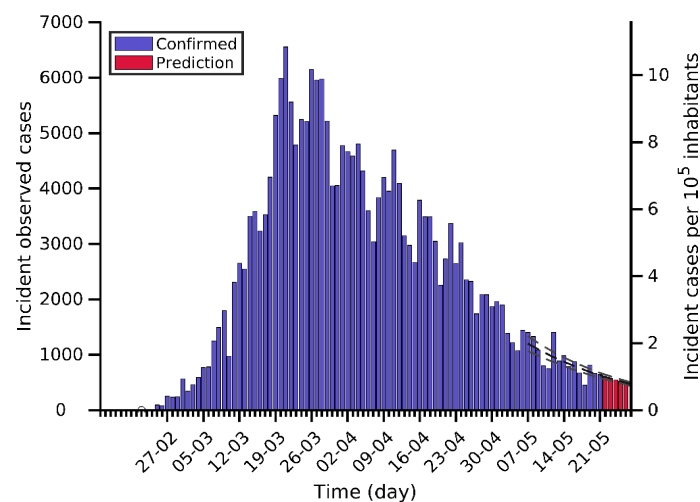
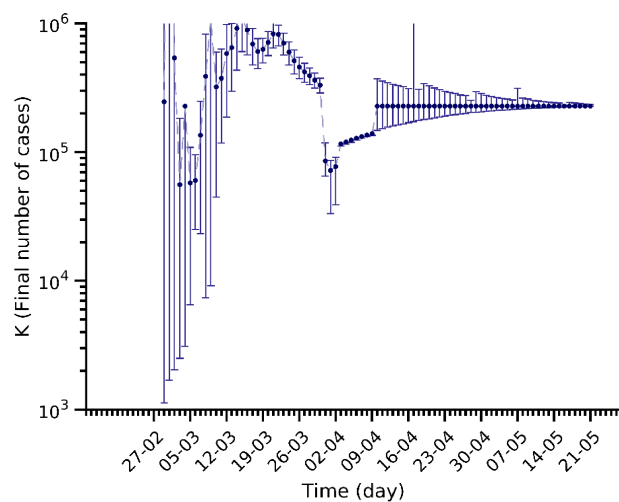
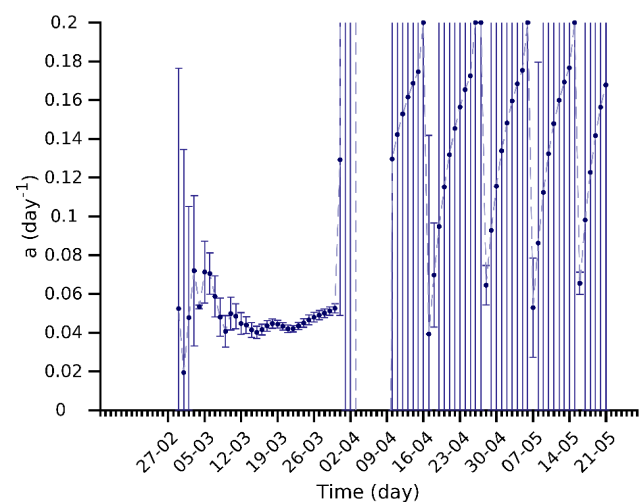
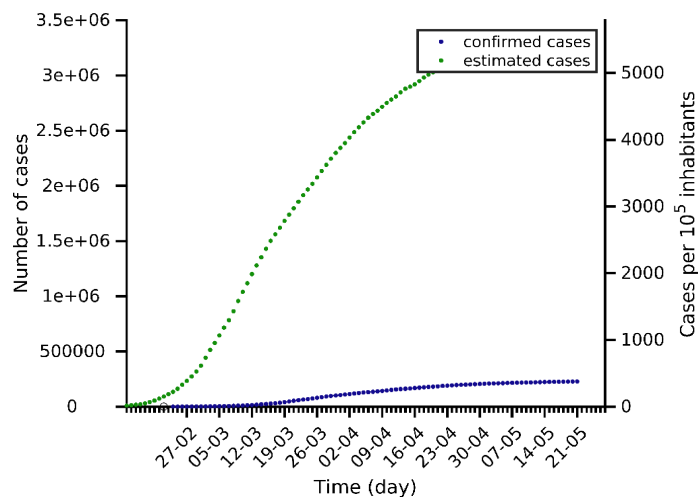
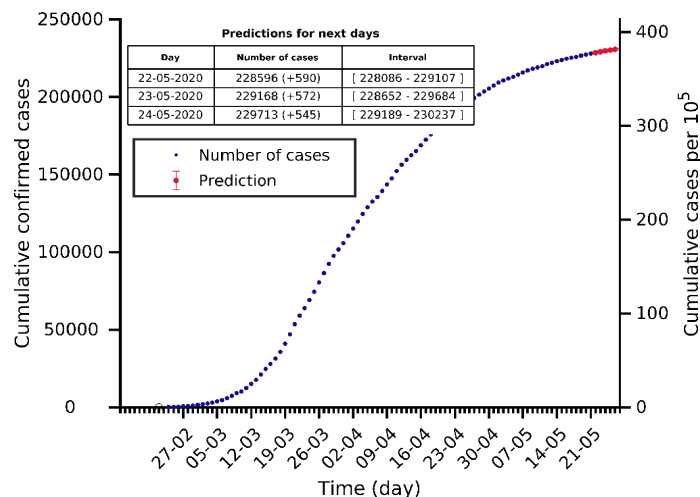


## **(4) Analysis and prediction of COVID-19 for Italy and its regions**

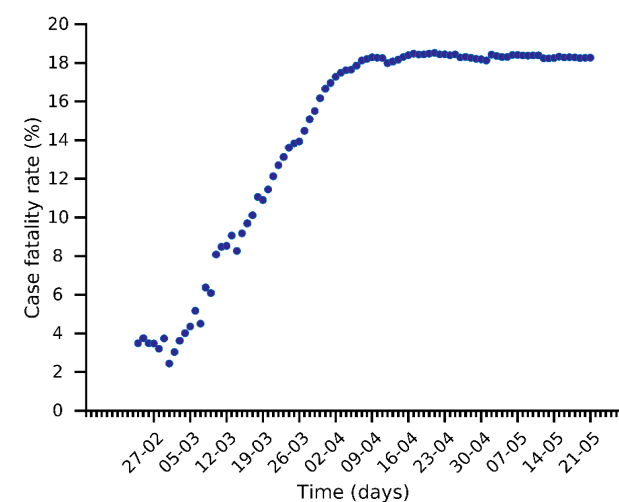
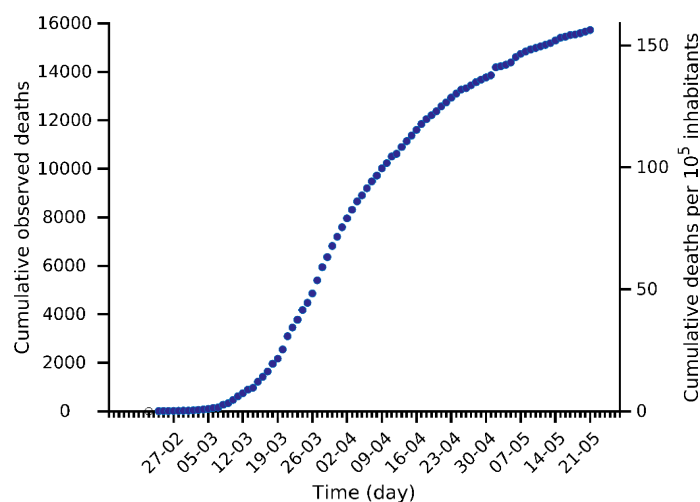
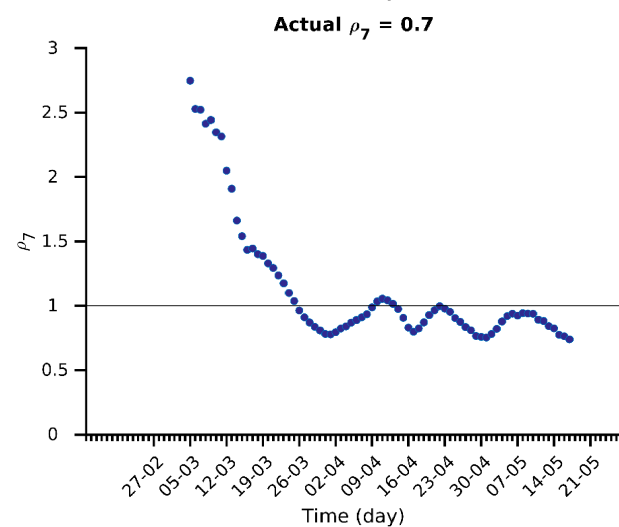
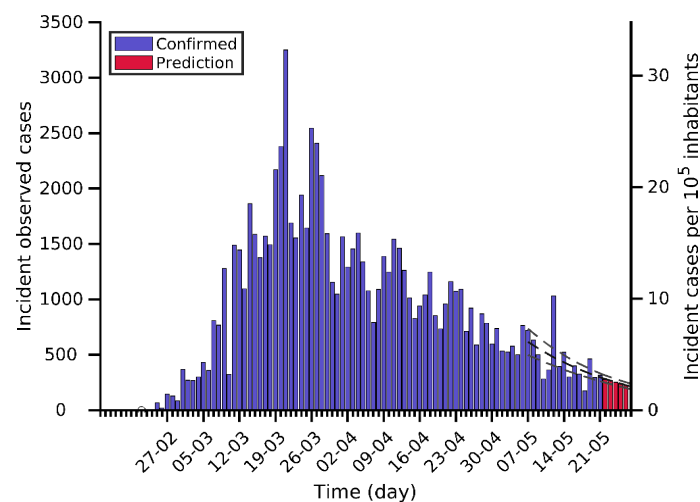
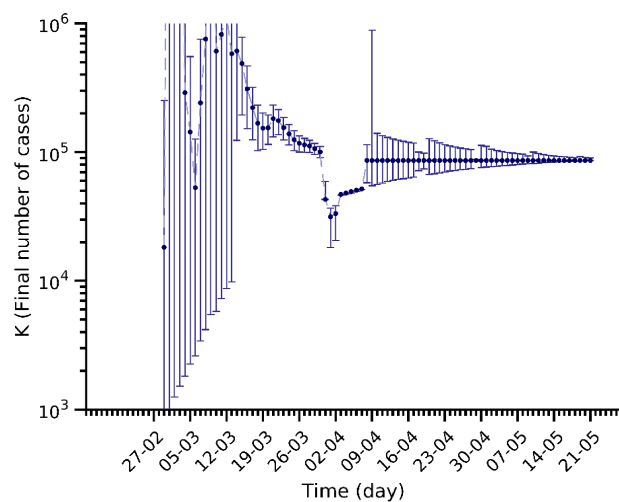
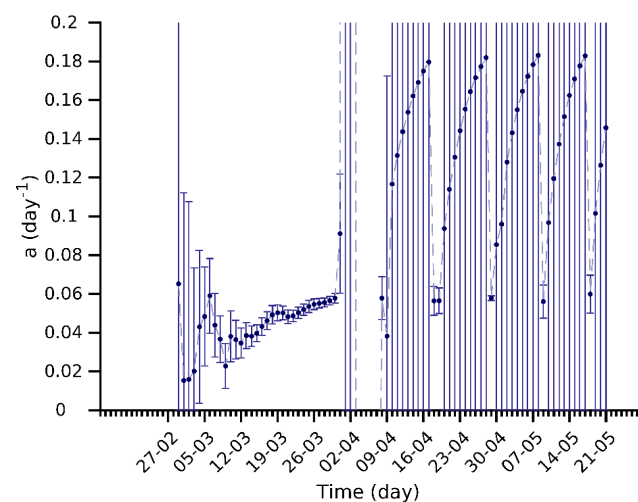
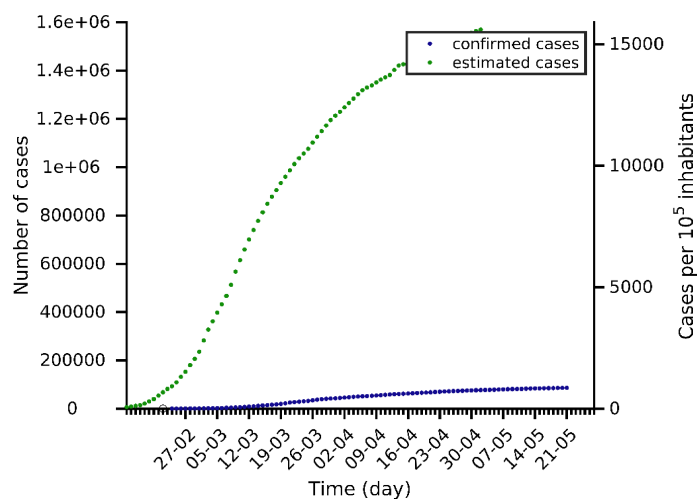
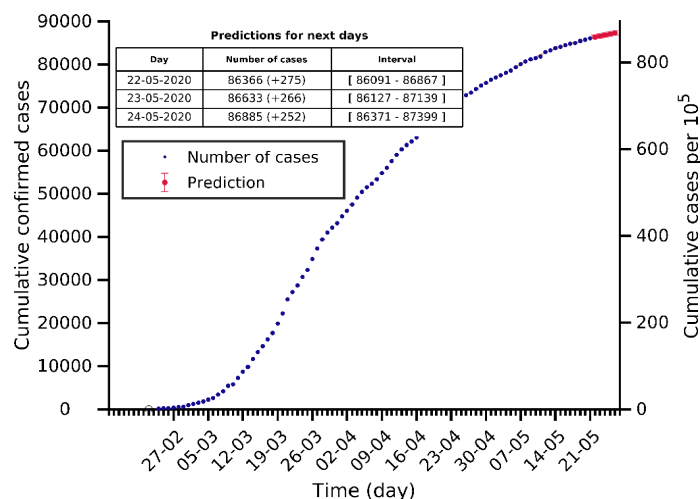
Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>



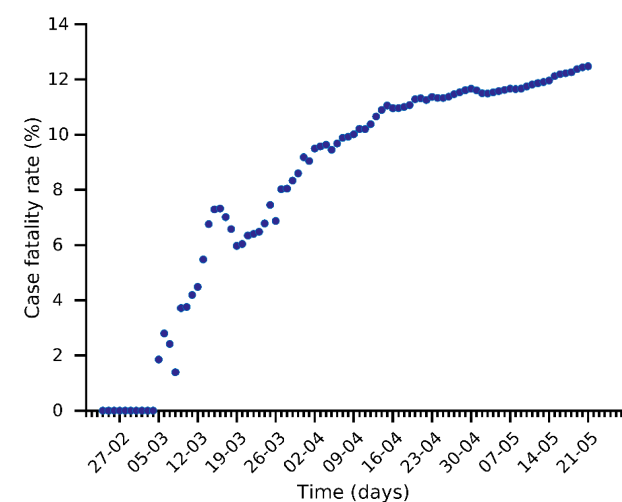
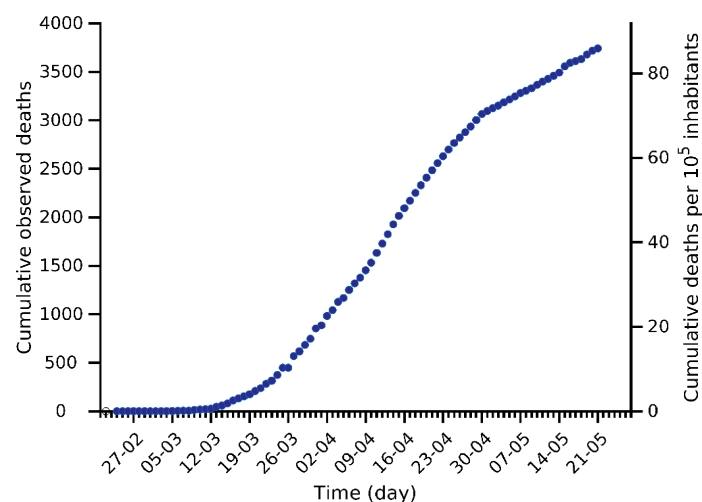
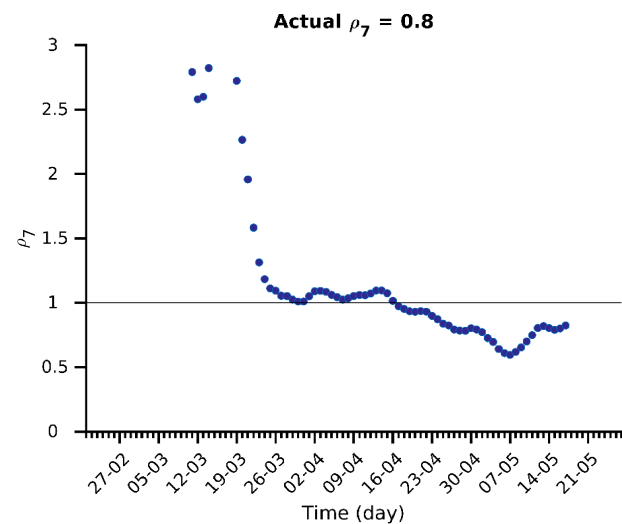
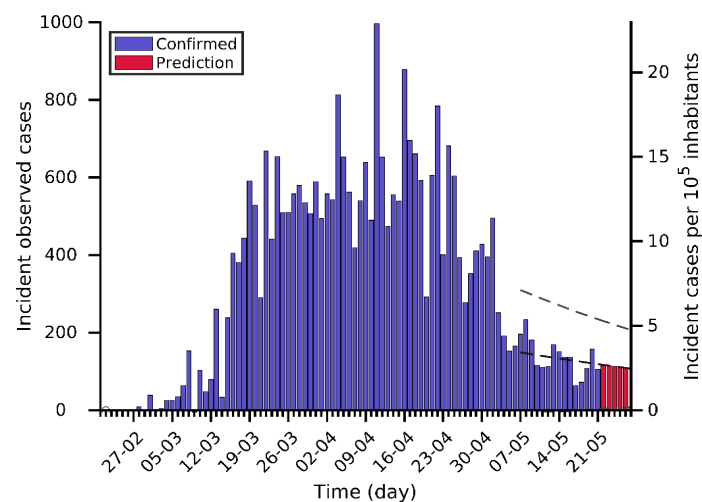
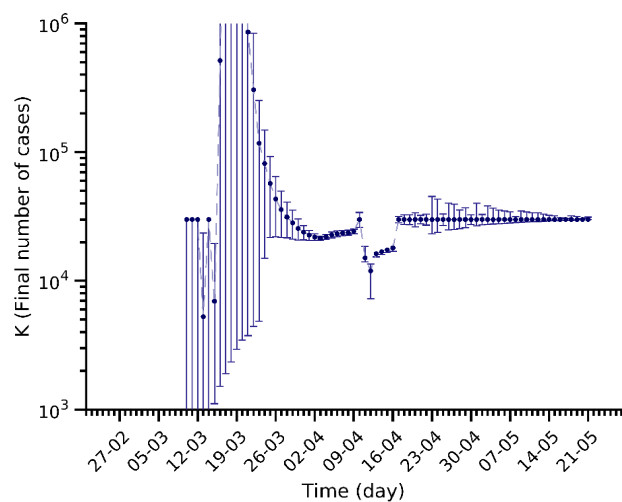
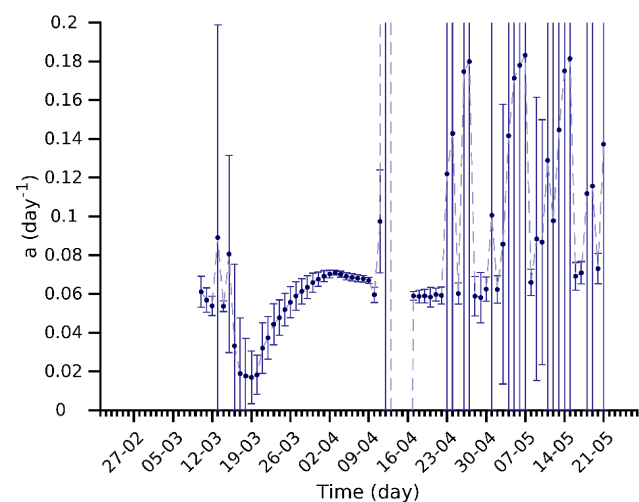
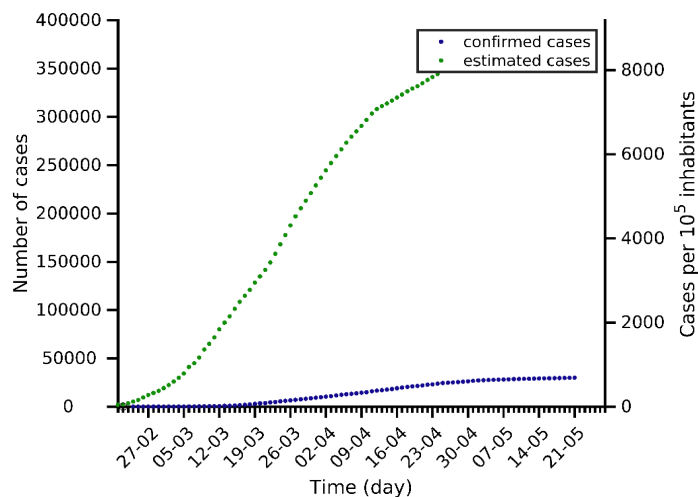
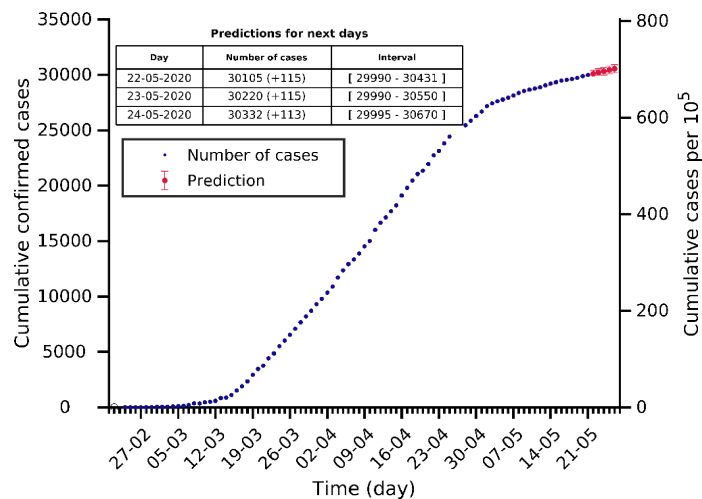
# Italy 21-05-2020. Population: 60.5M. Current cumulated incidence: 377/10<sup>5</sup>



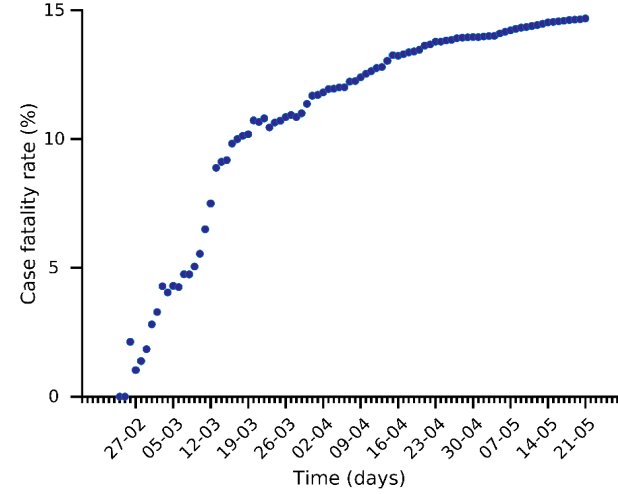
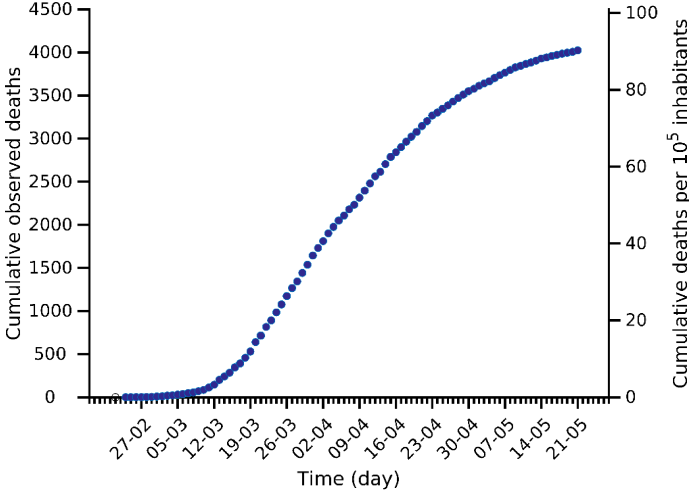
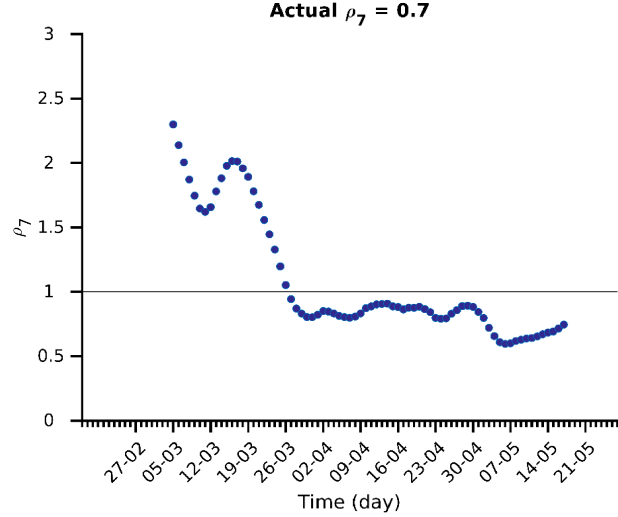
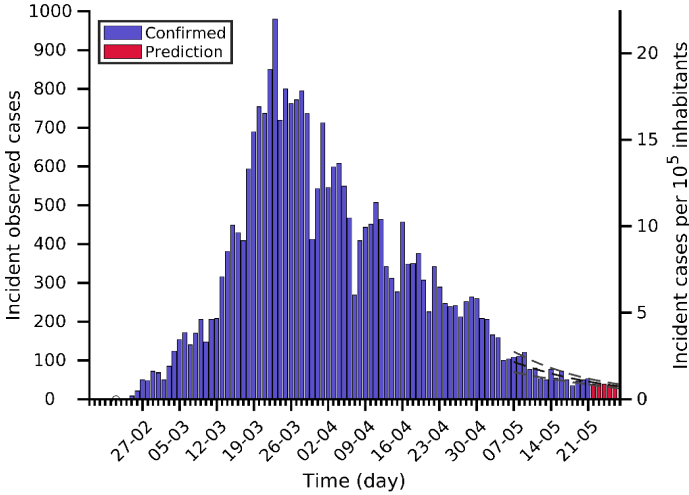
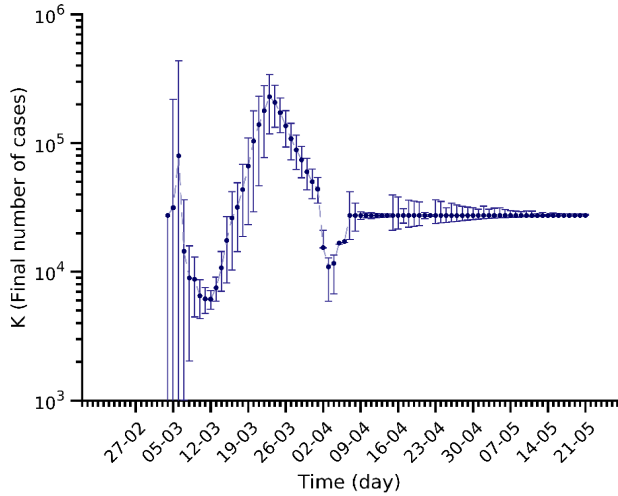
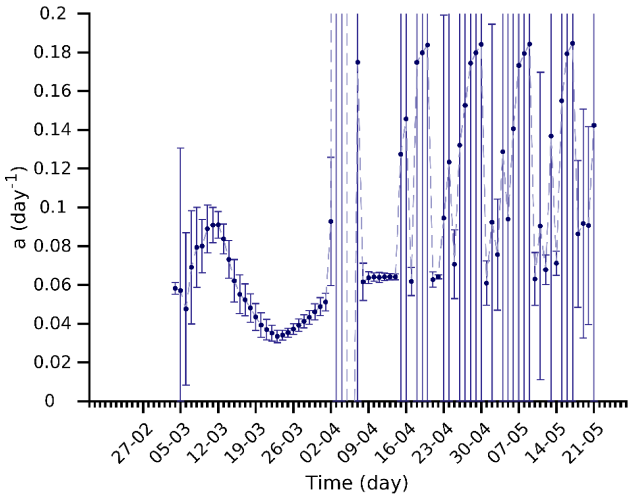
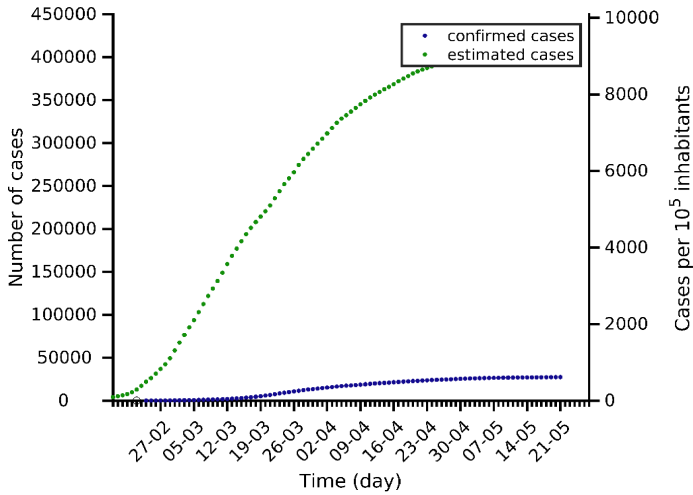
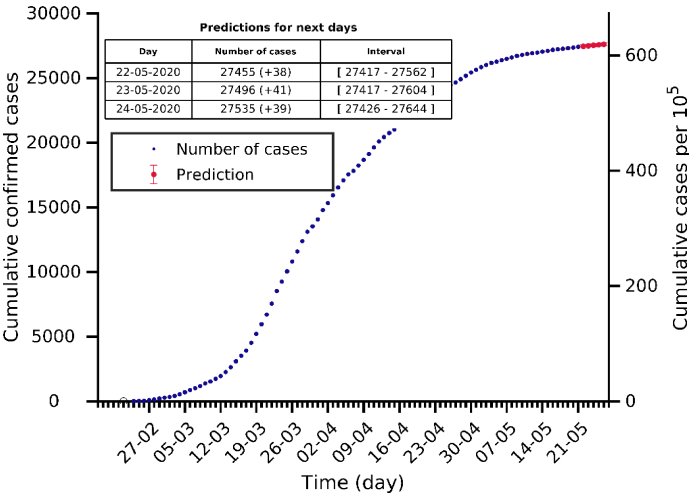
# Lombardia 21-05-2020. Population: 10.1M. Current cumulated incidence: 856/10<sup>5</sup>



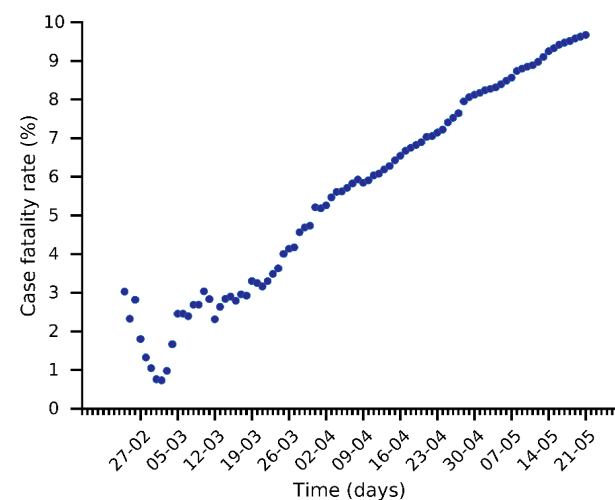
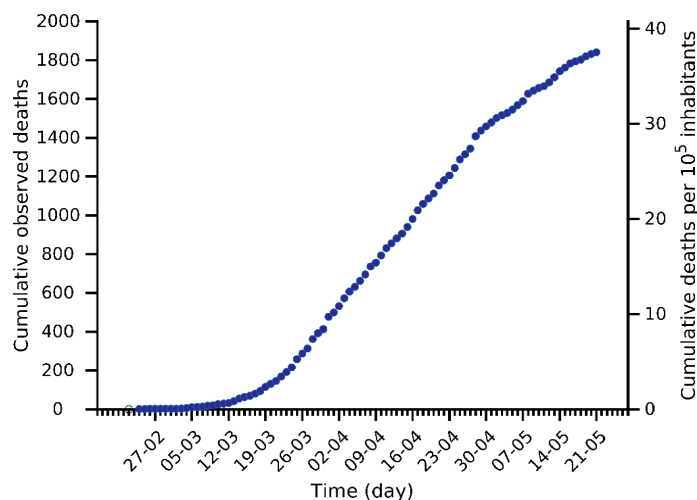
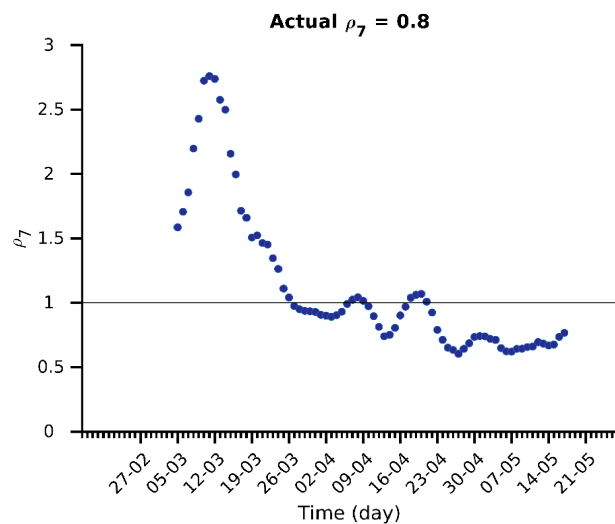
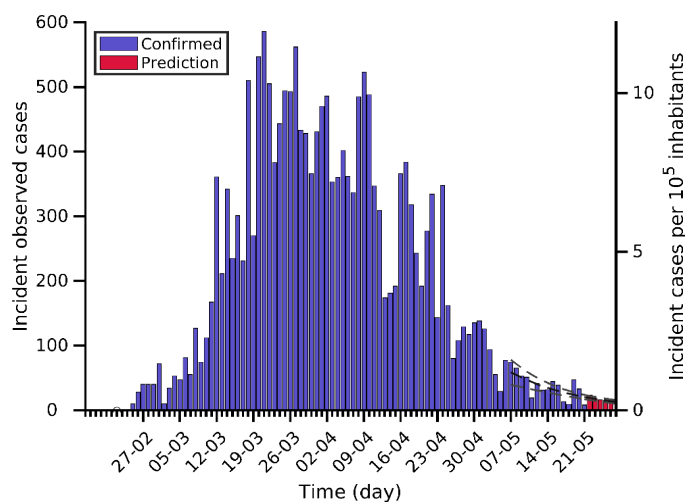
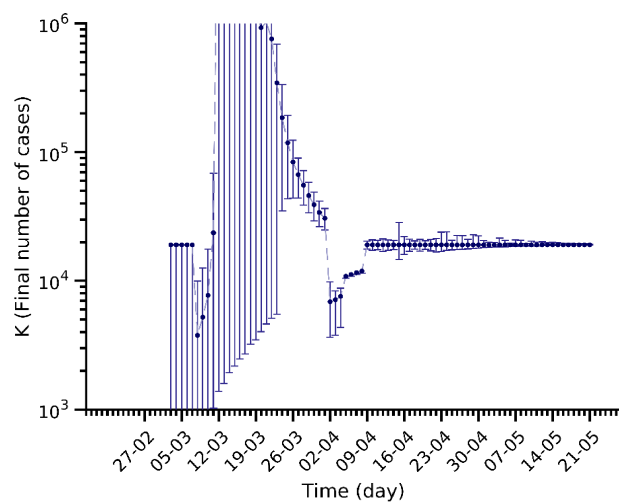
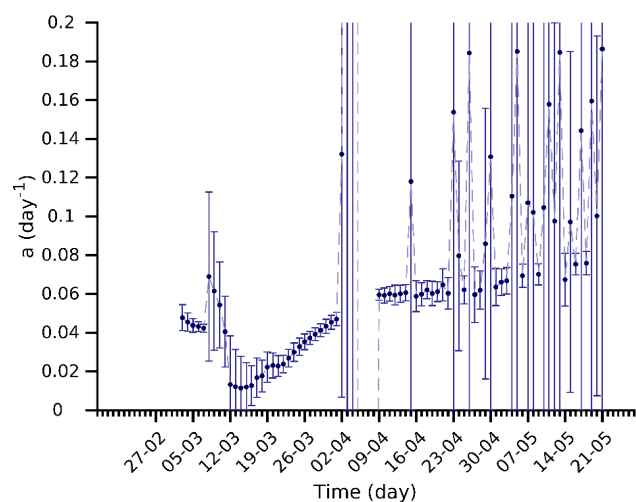
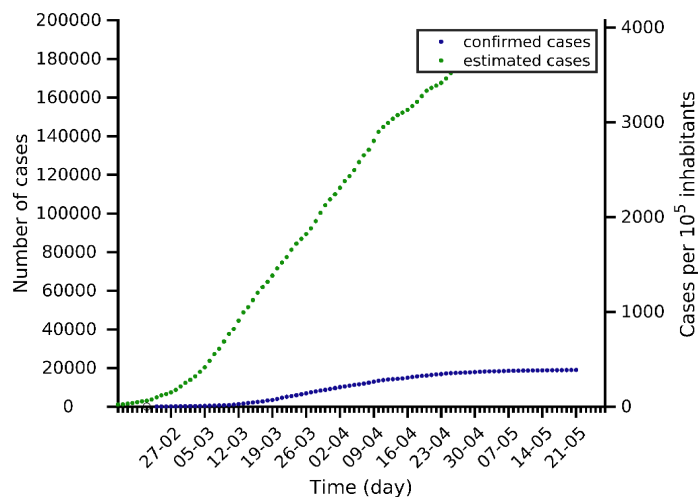
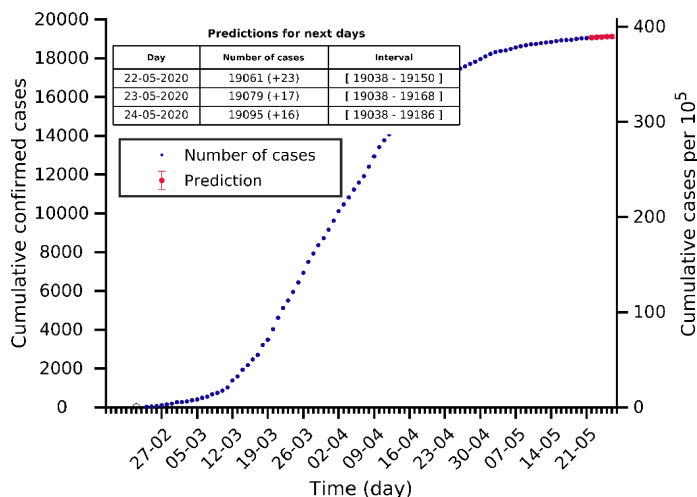
# Piemonte 21-05-2020. Population: 4.4M. Current cumulated incidence: 688/10<sup>5</sup>



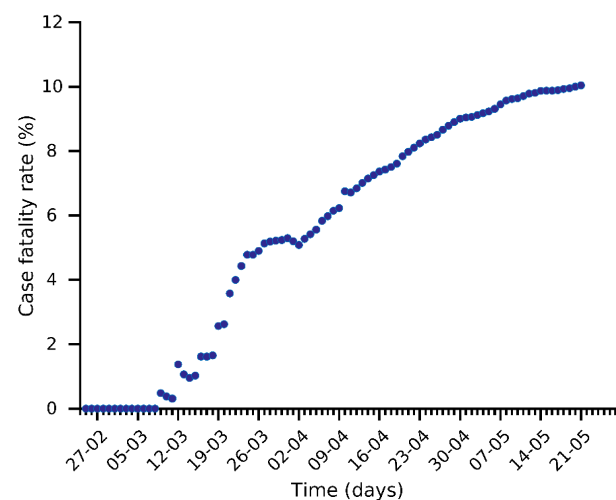
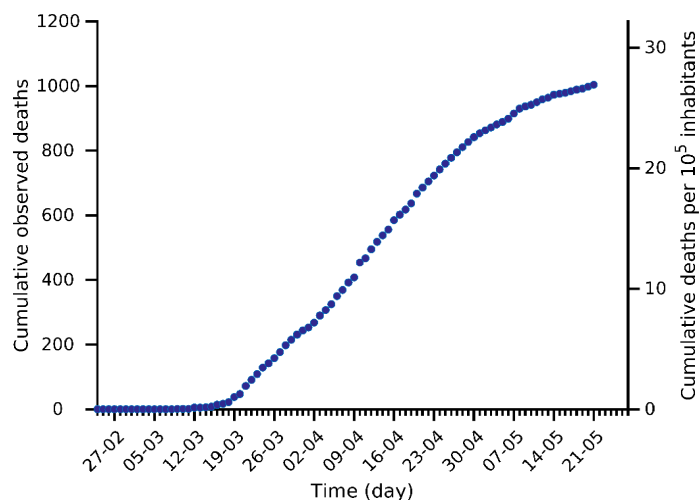
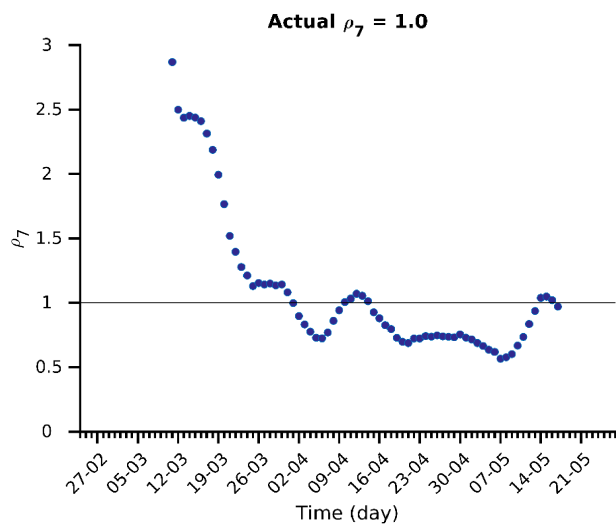
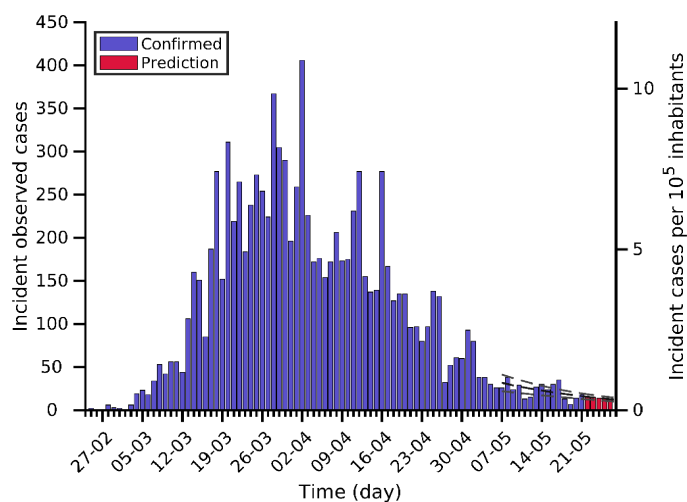
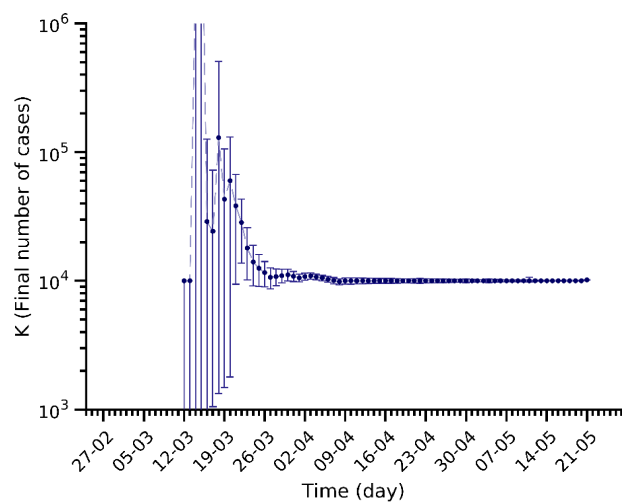
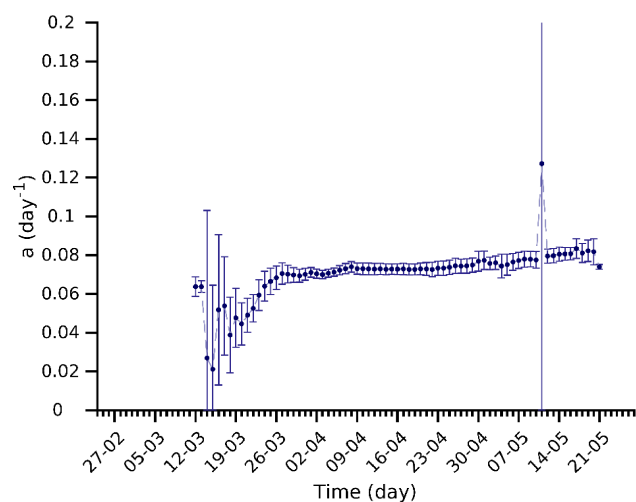
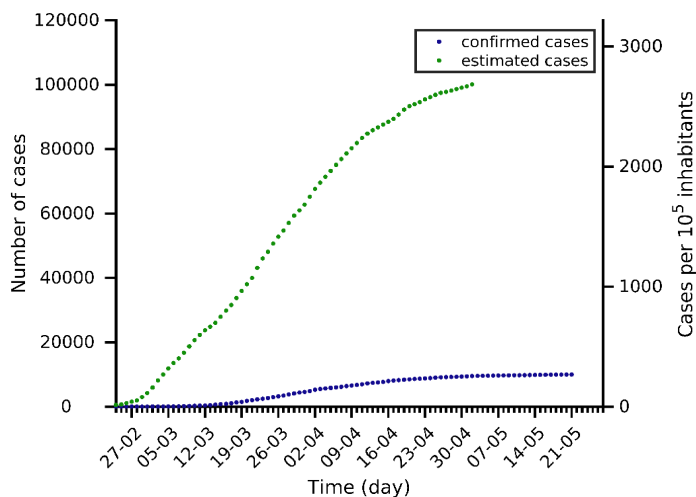
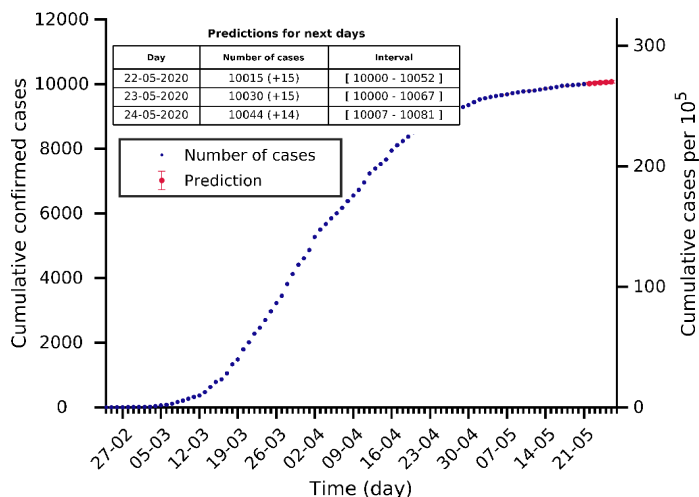
Emilia Romagna 21-05-2020. Population: 4.5M. Current cumulated incidence: 615/100000



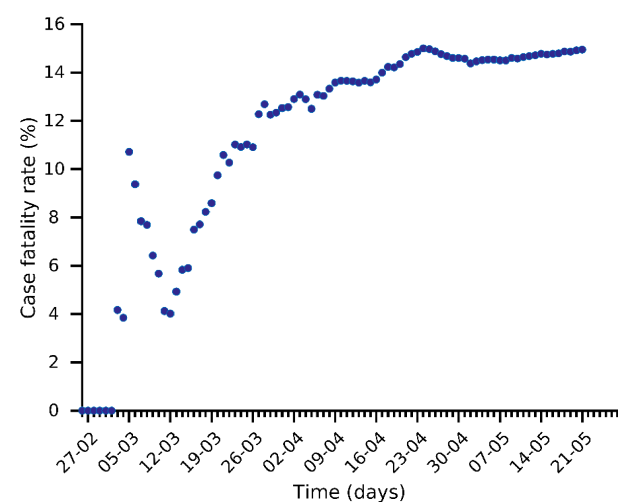
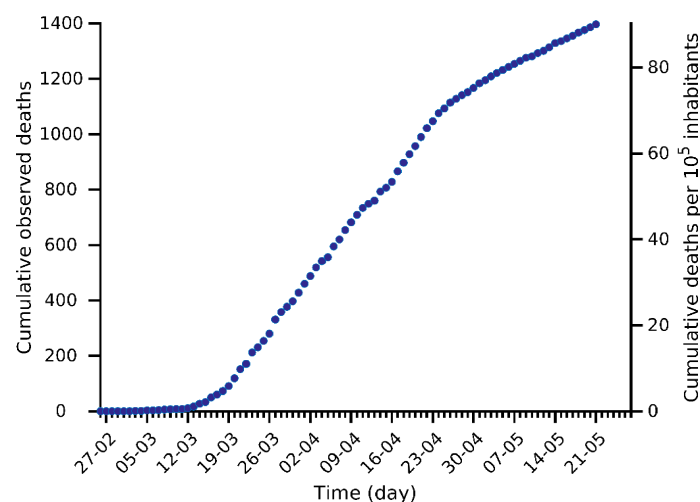
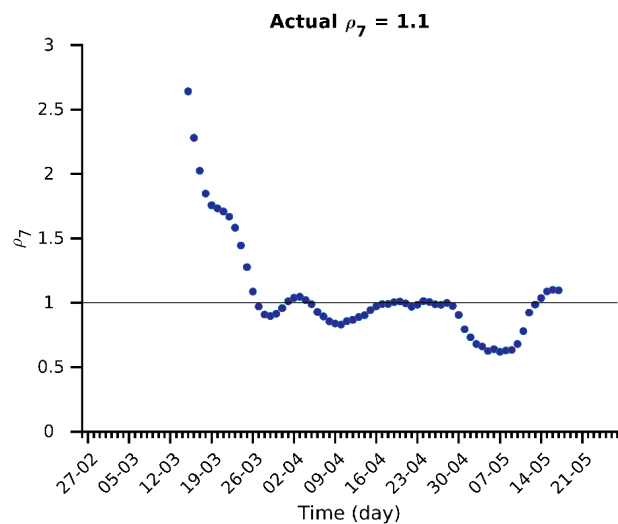
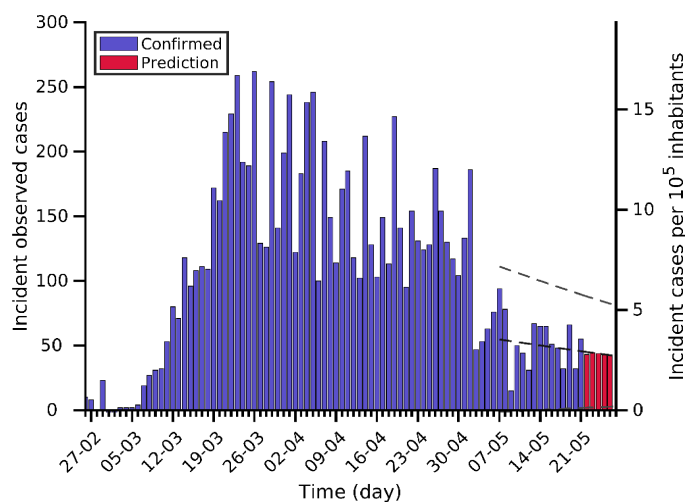
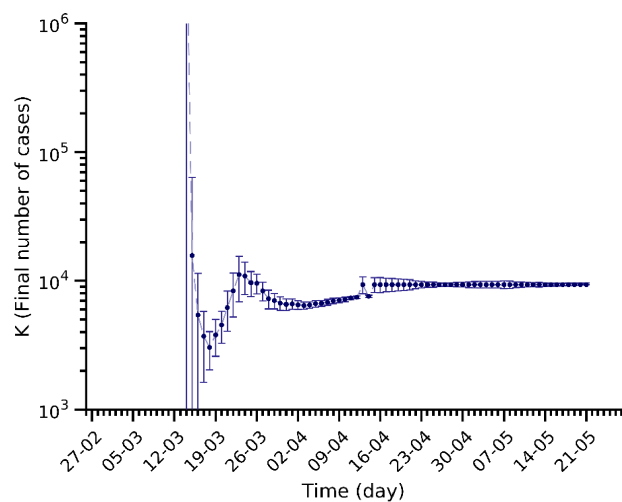
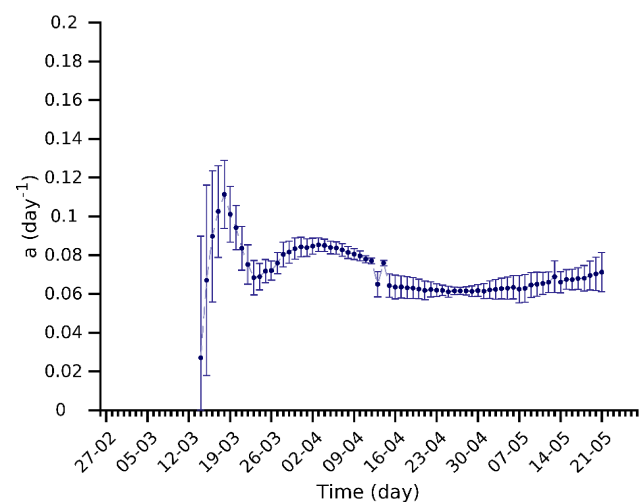
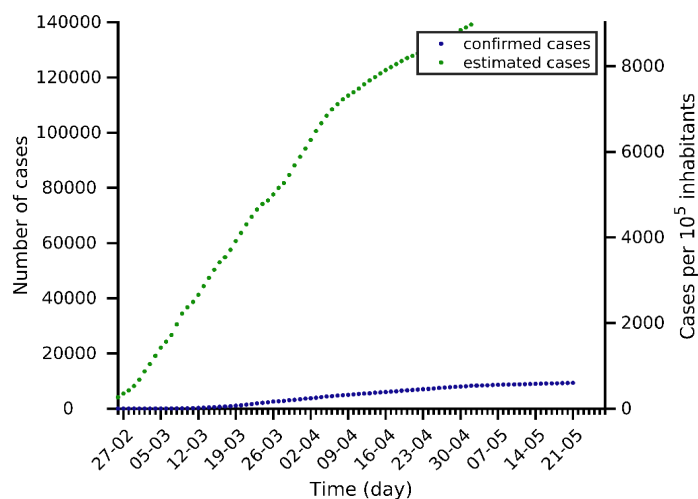
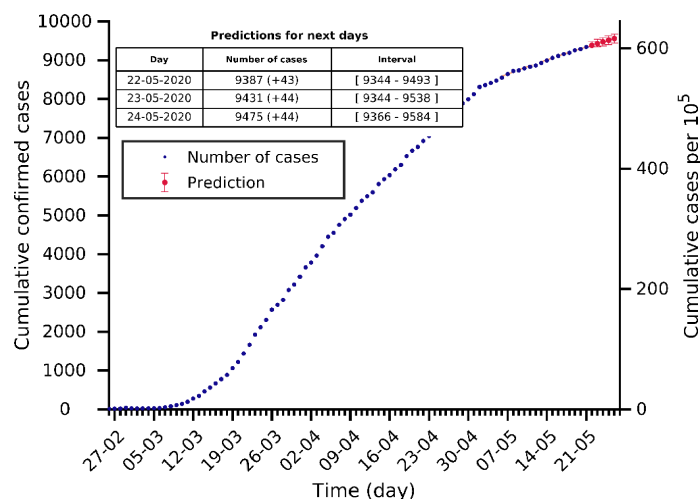
# Veneto 21-05-2020. Population: 4.9M. Current cumulated incidence: 388/10<sup>5</sup>



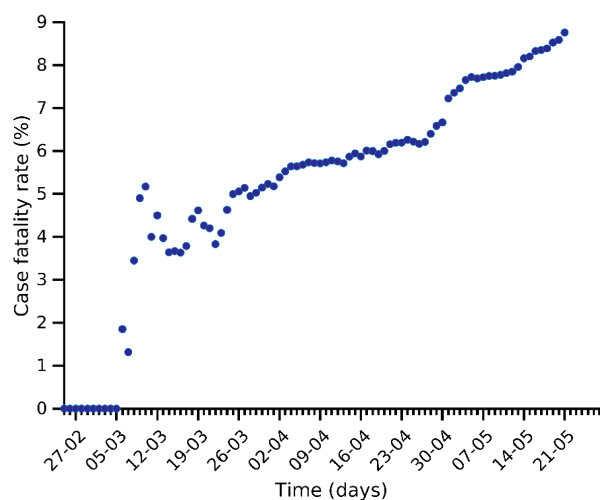
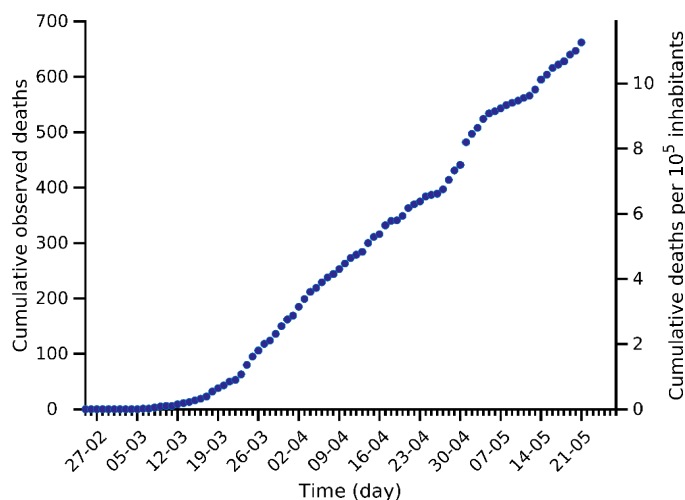
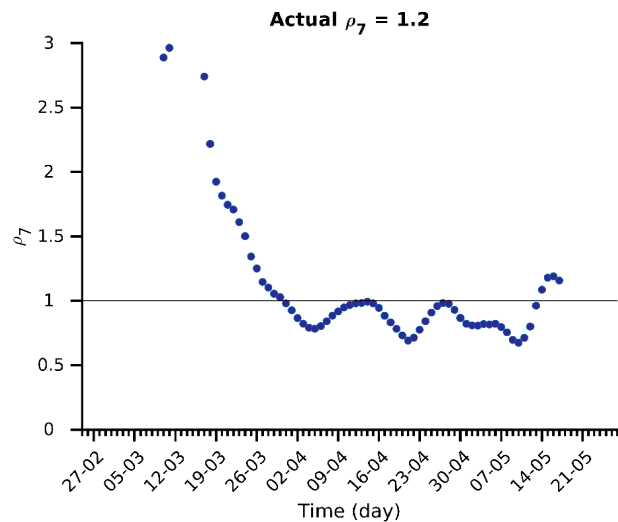
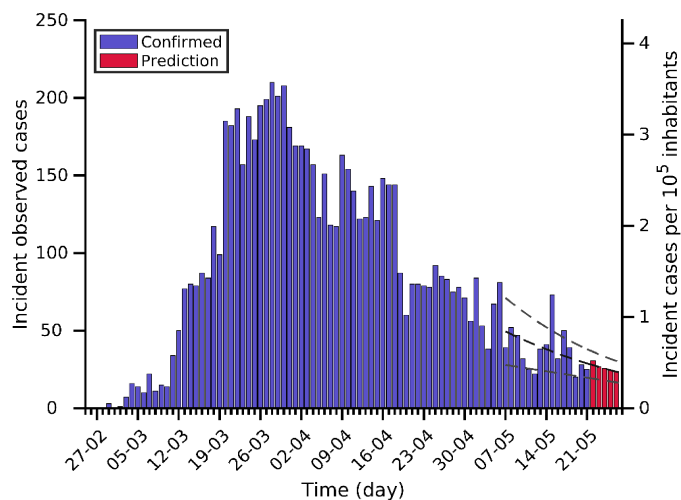
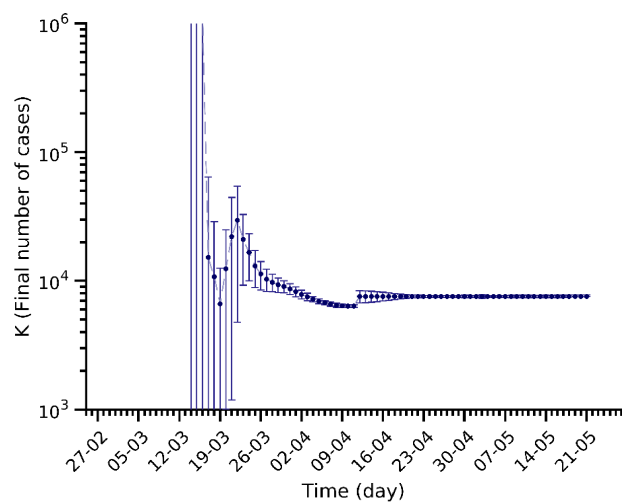
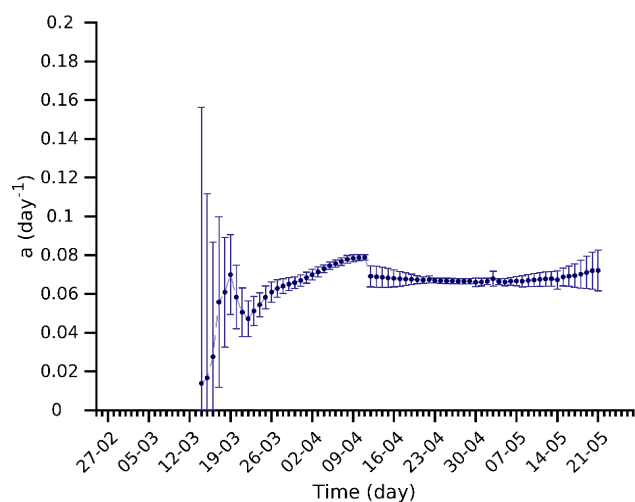
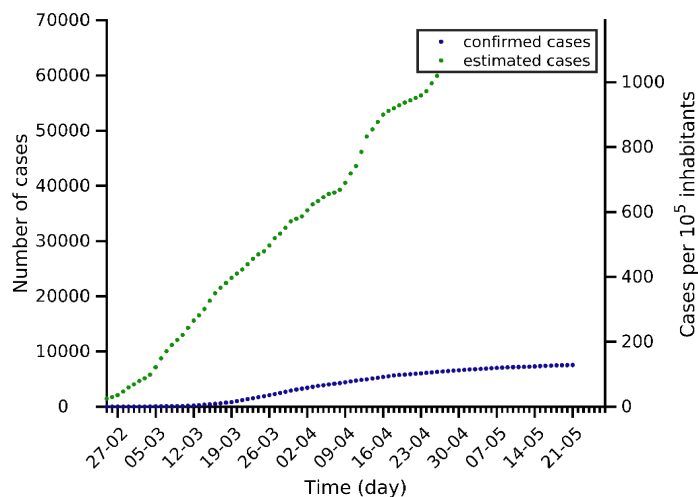
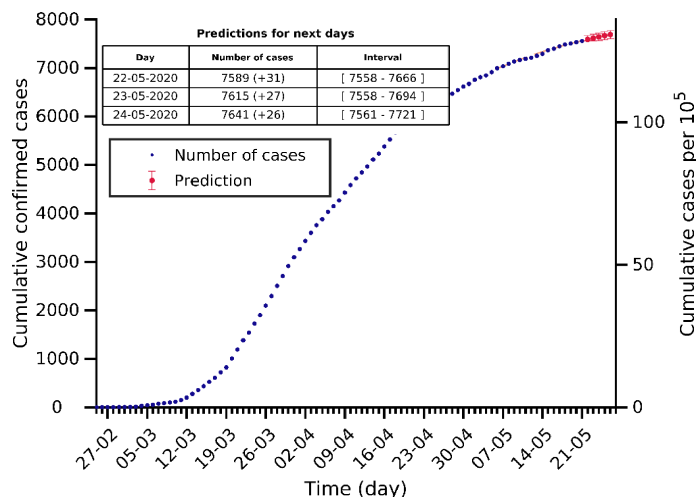
# Toscana 21-05-2020. Population: 3.7M. Current cumulated incidence: 268/10<sup>5</sup>



# Liguria 21-05-2020. Population: 1.6M. Current cumulated incidence: 602/10<sup>5</sup>

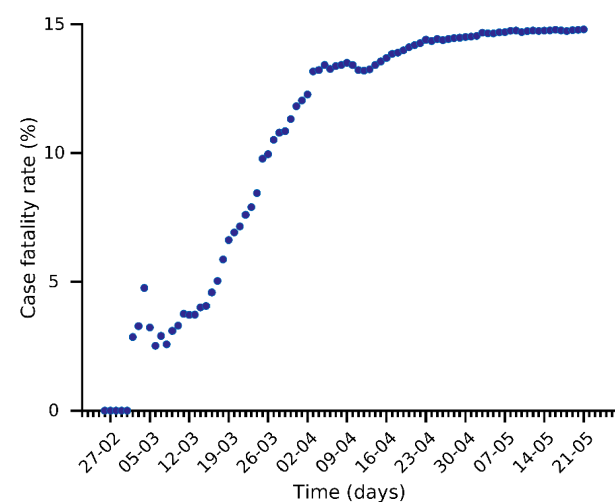
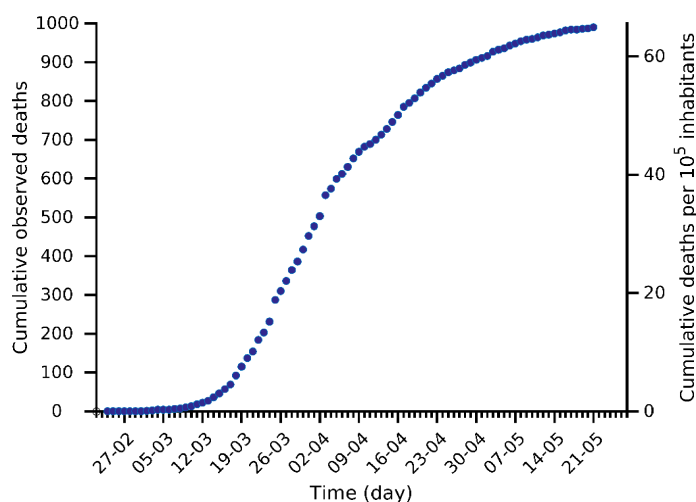
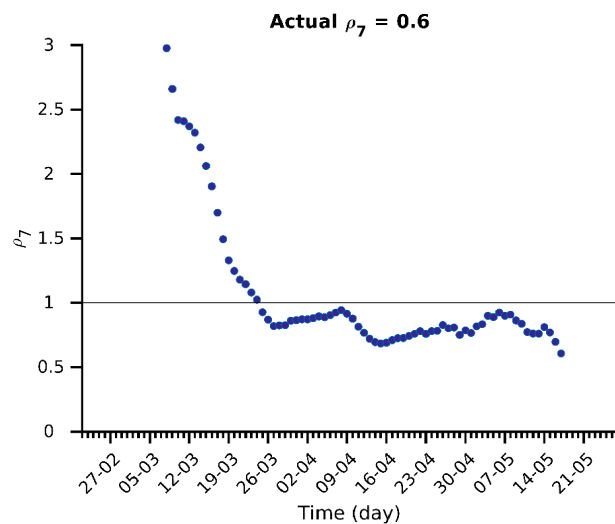
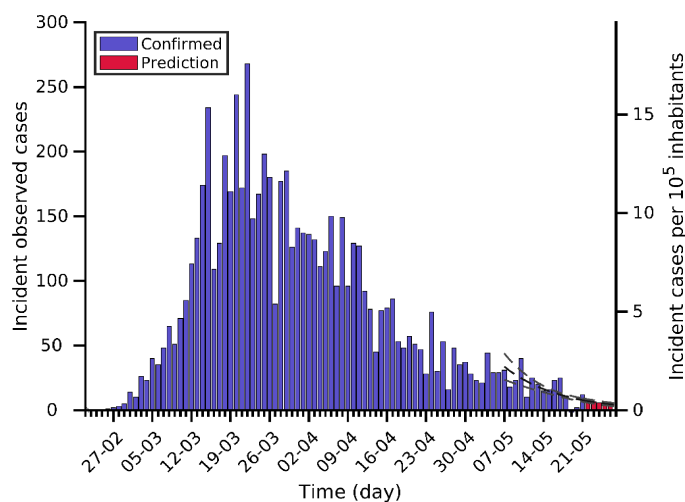
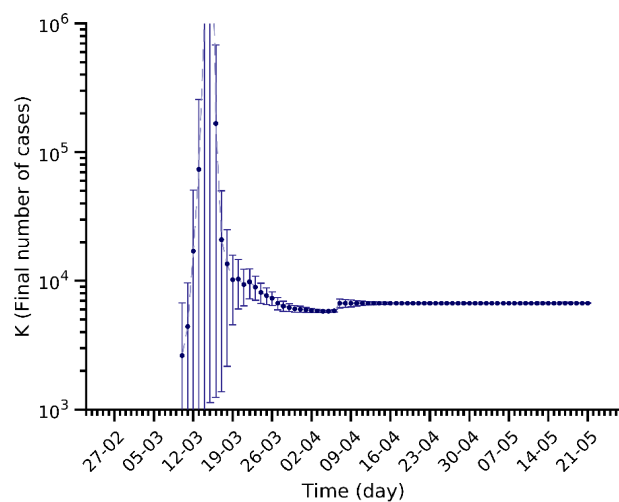
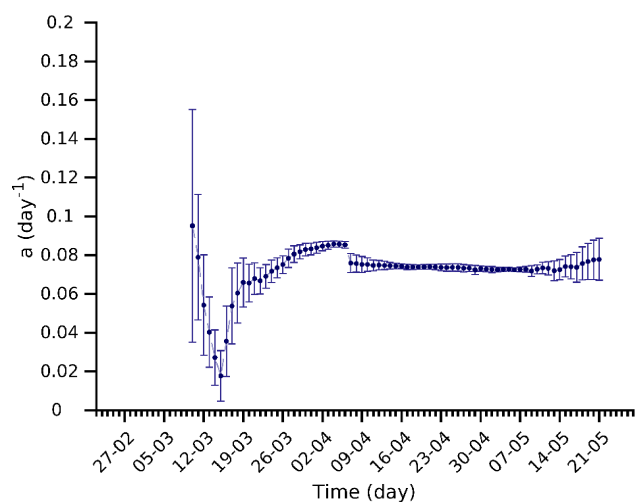
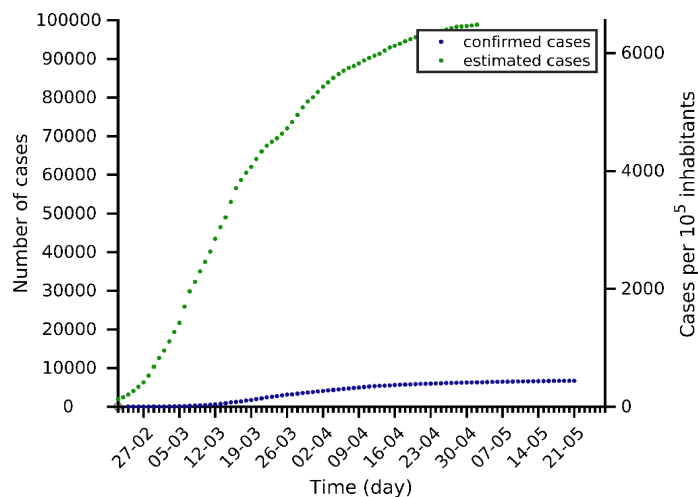
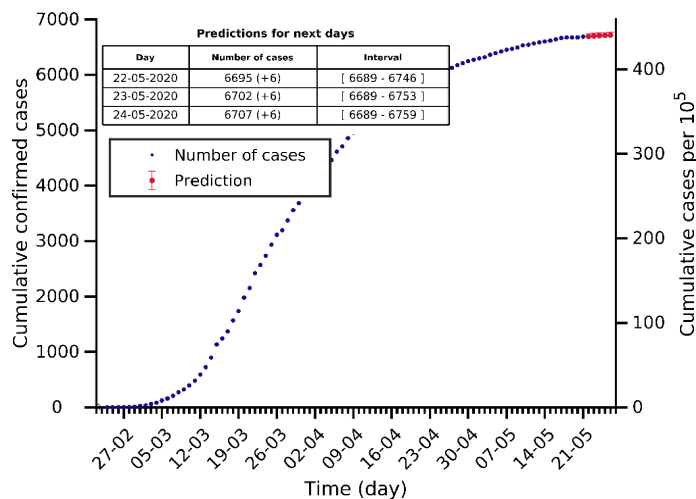


# Lazio 21-05-2020. Population: 5.9M. Current cumulated incidence: 129/10<sup>5</sup>

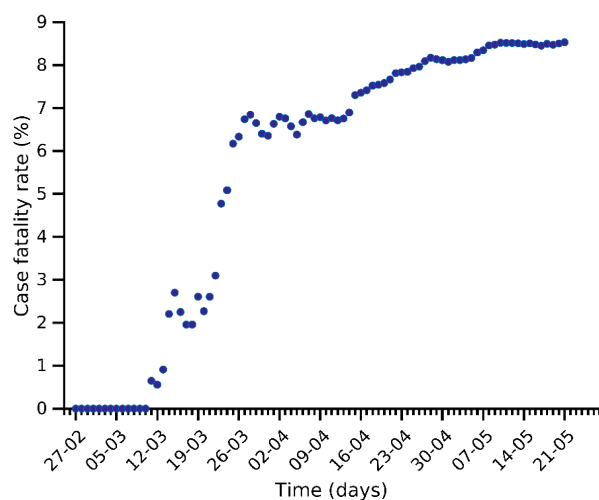
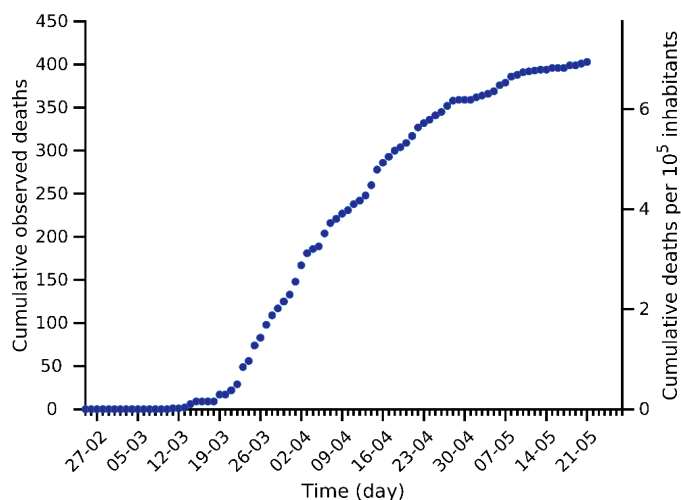
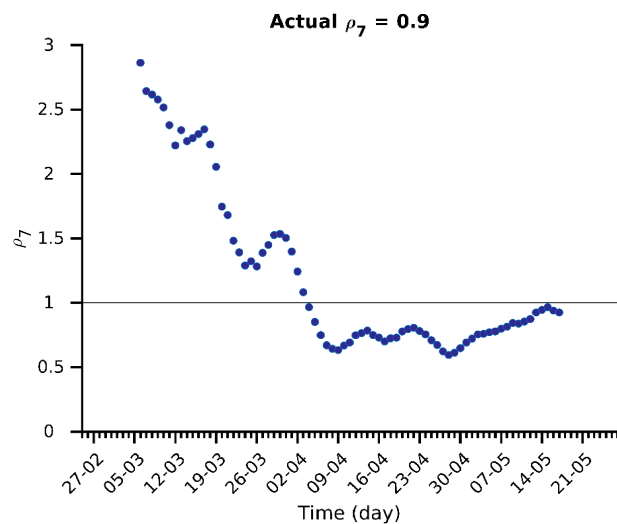
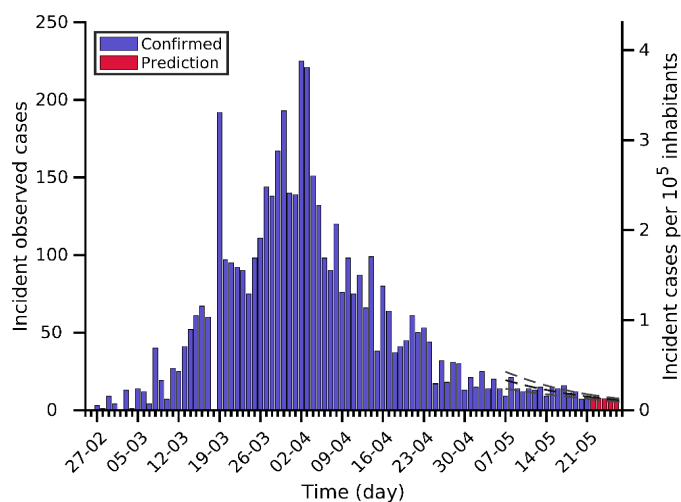
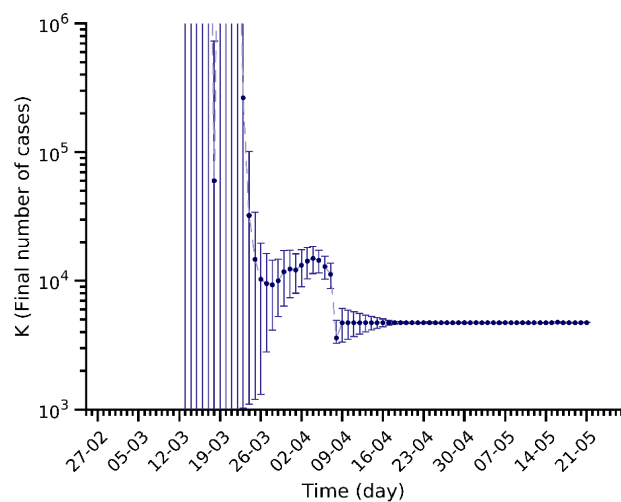
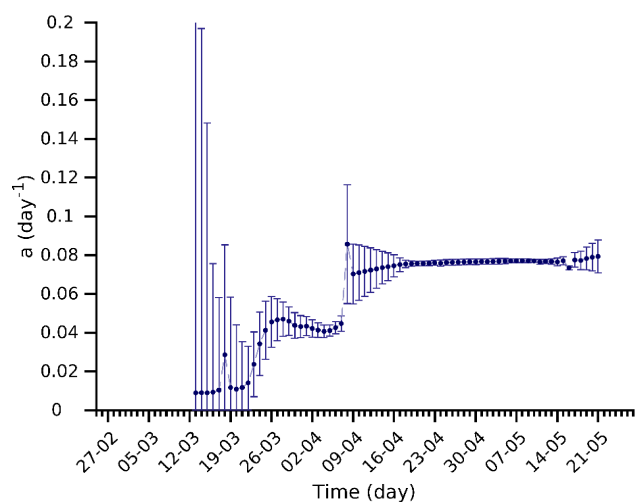
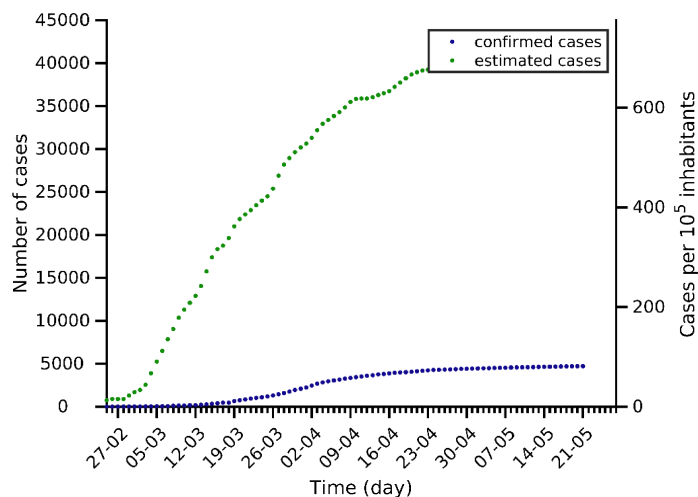
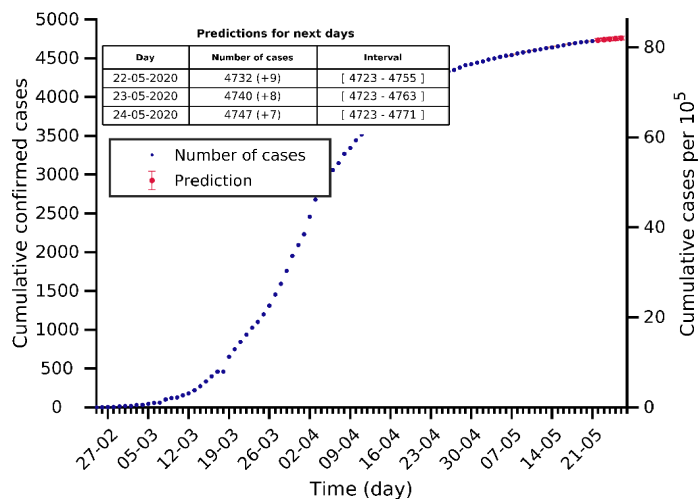




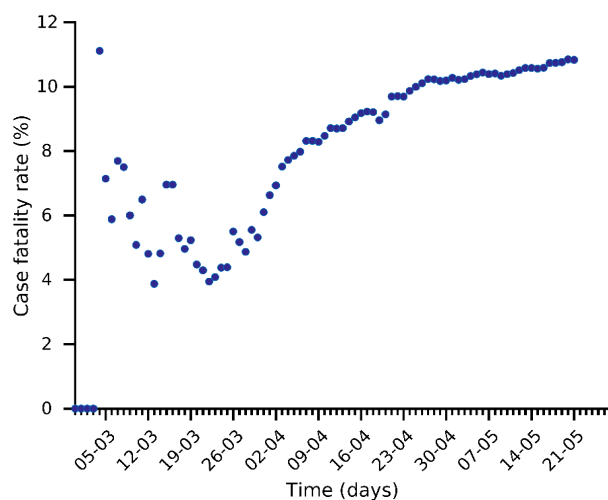
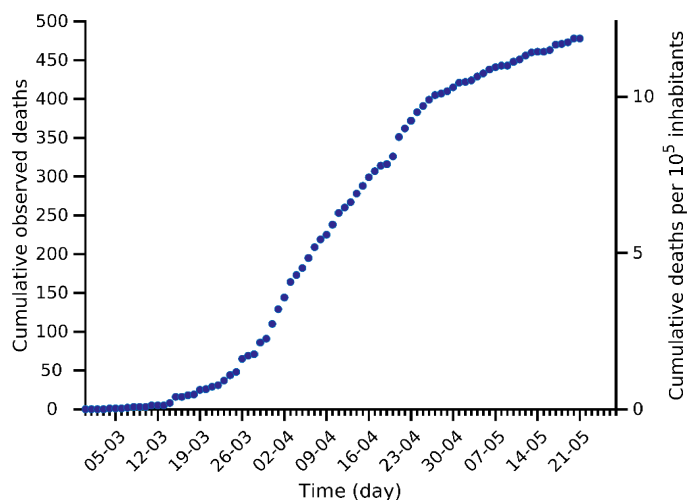
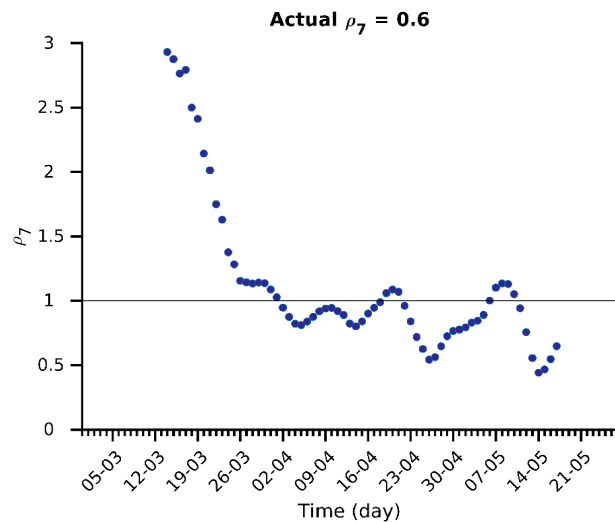
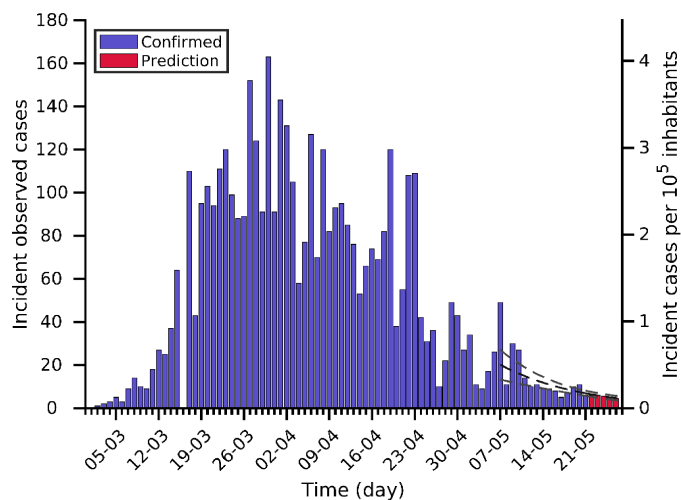
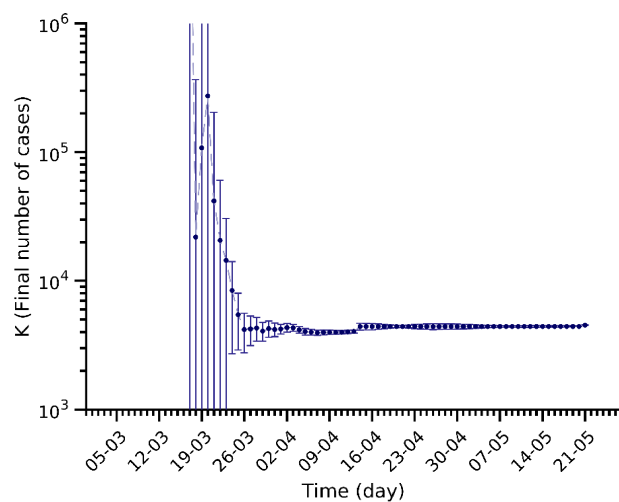
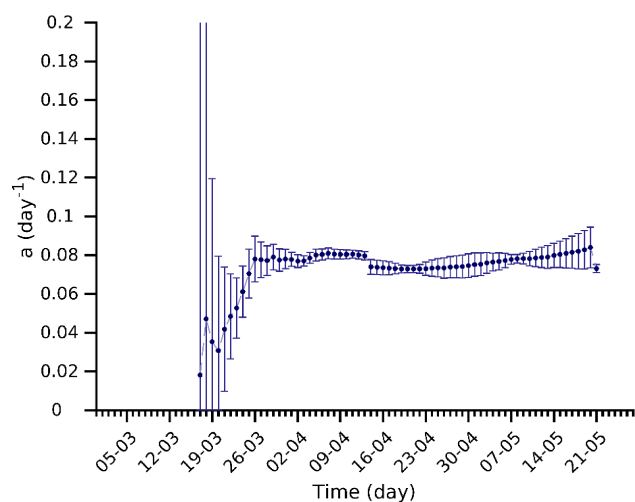
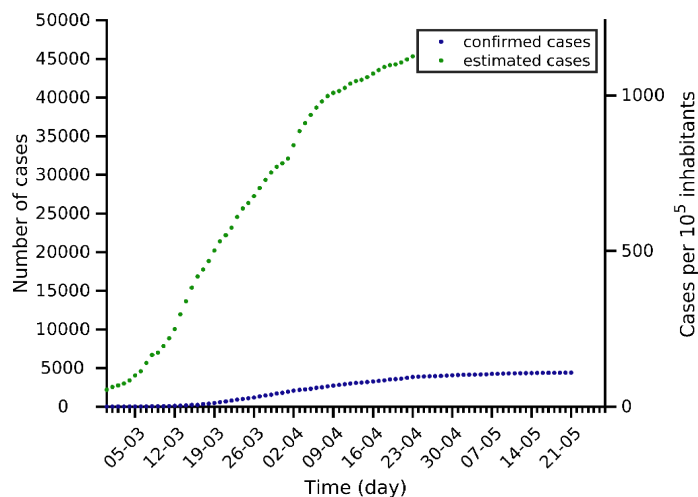
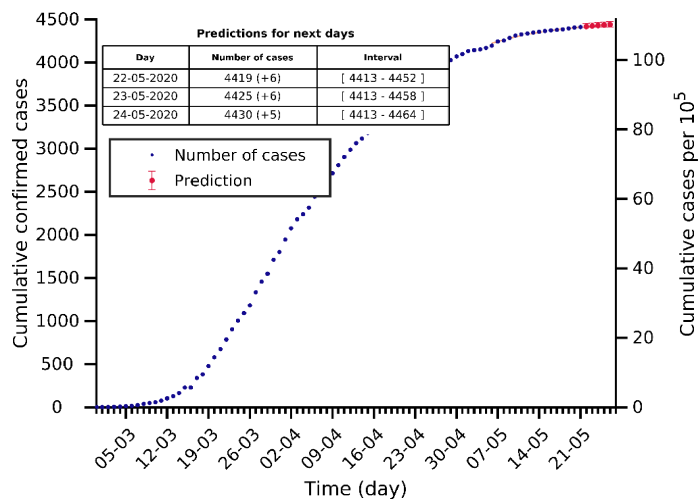
# **Marche 21-05-2020. Population: 1.5M. Current cumulated incidence: 439/10<sup>5</sup>**



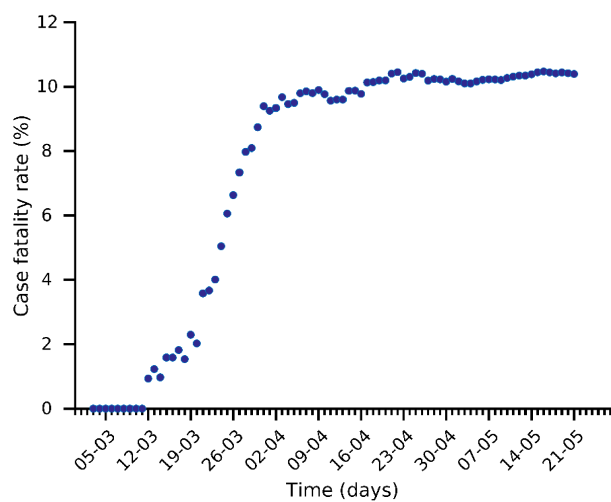
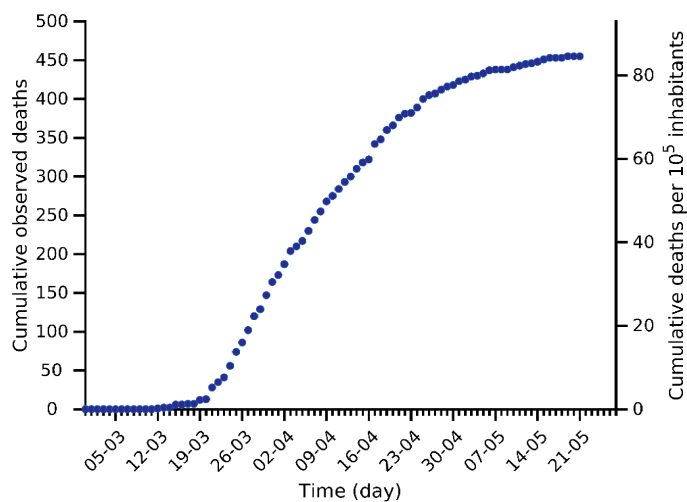
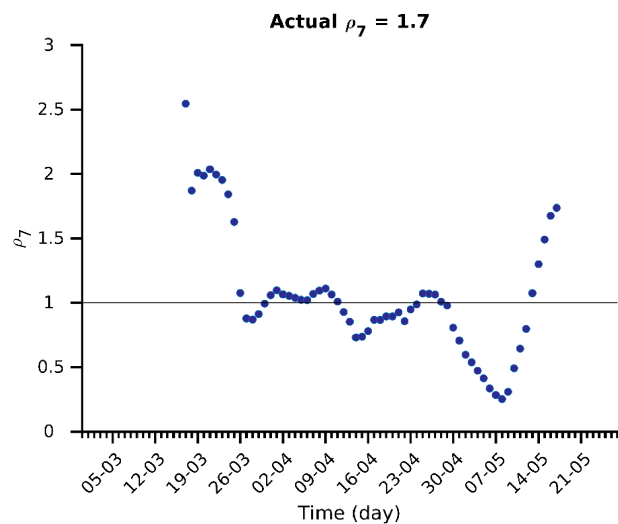
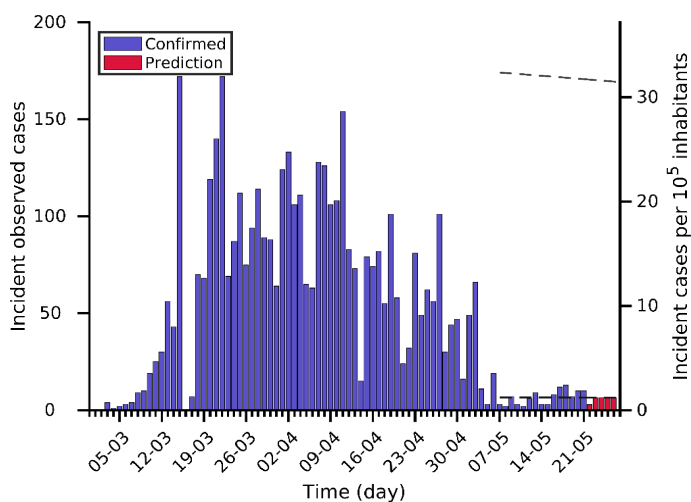
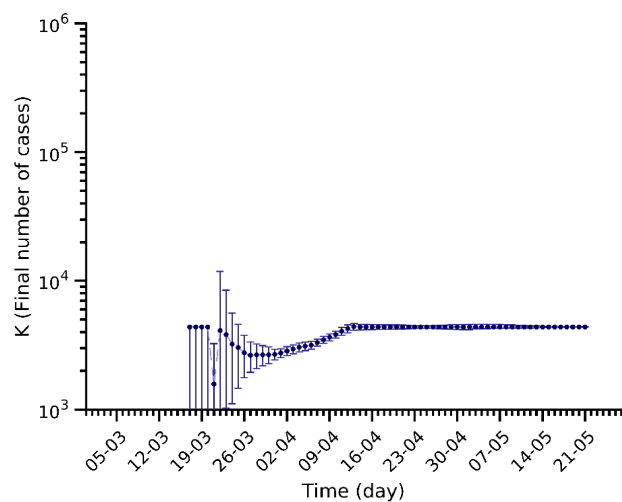
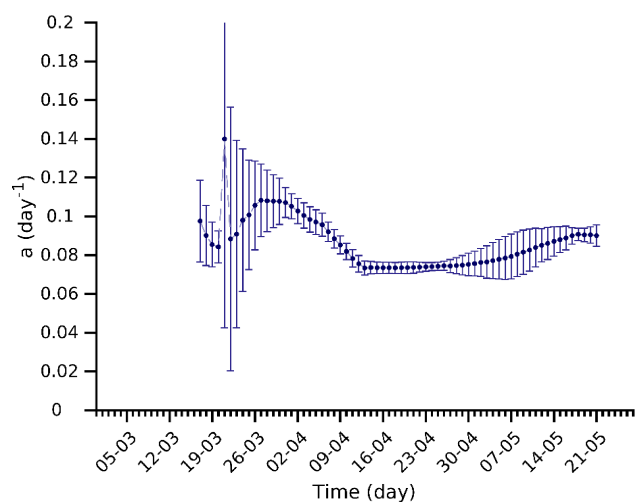
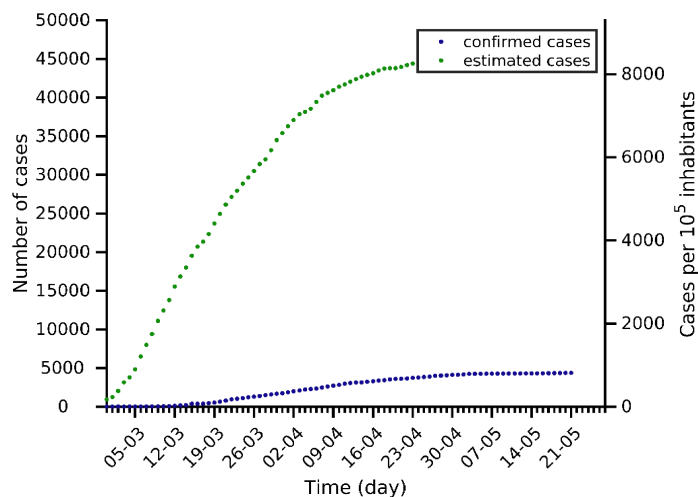
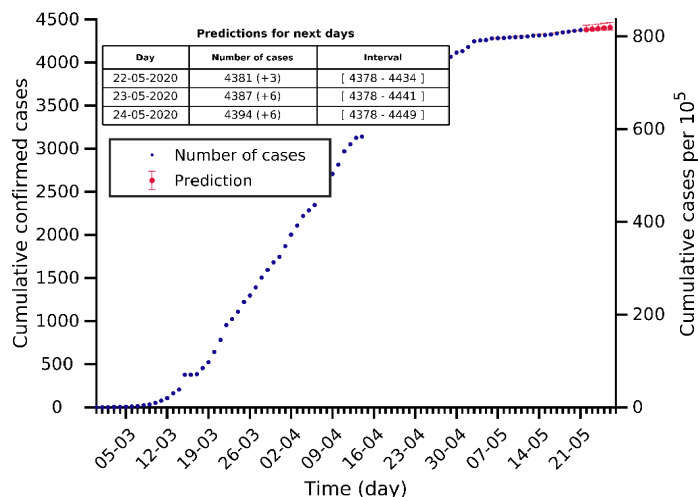
# Campania 21-05-2020. Population: 5.8M. Current cumulated incidence: 81/10<sup>5</sup>



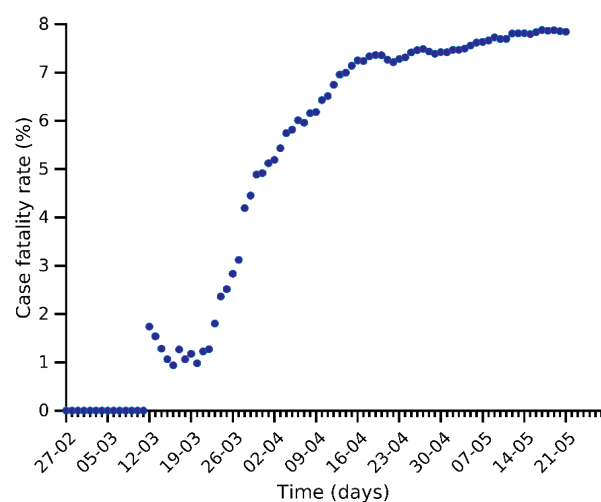
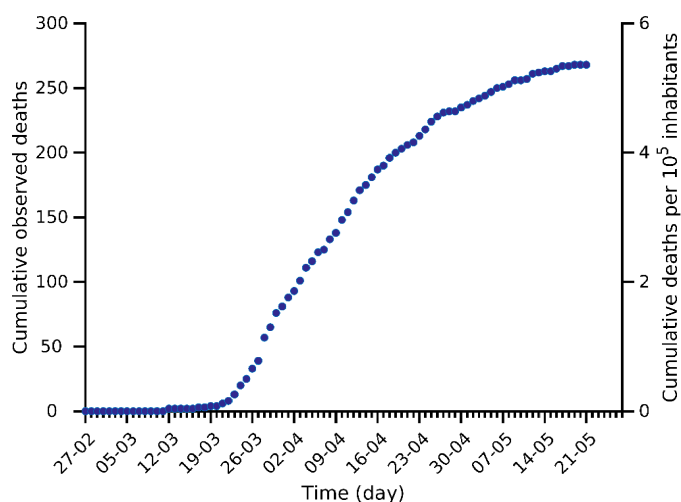
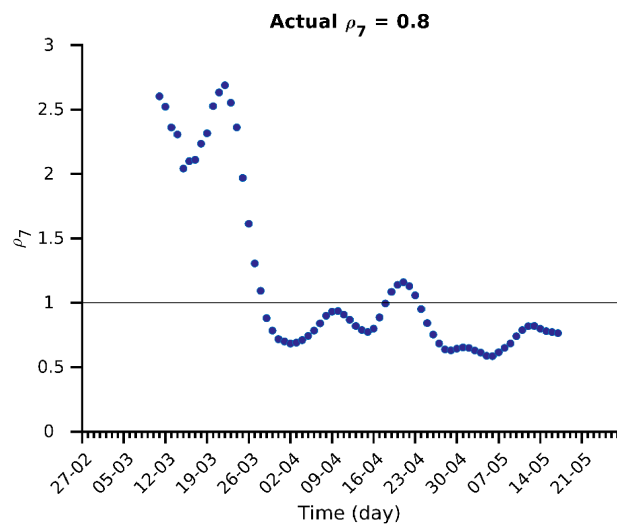
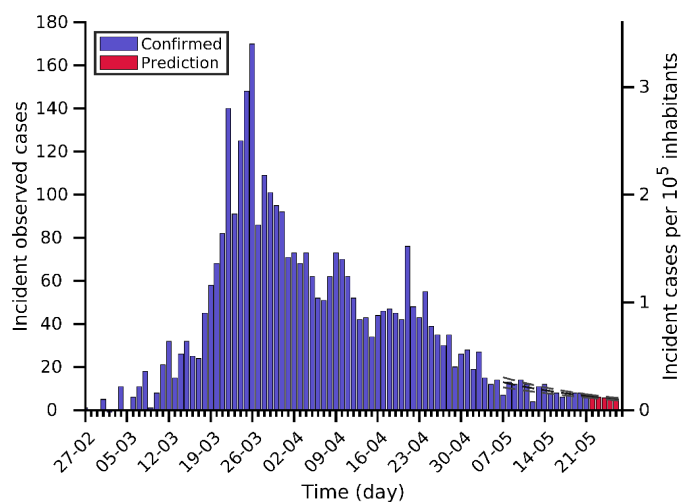
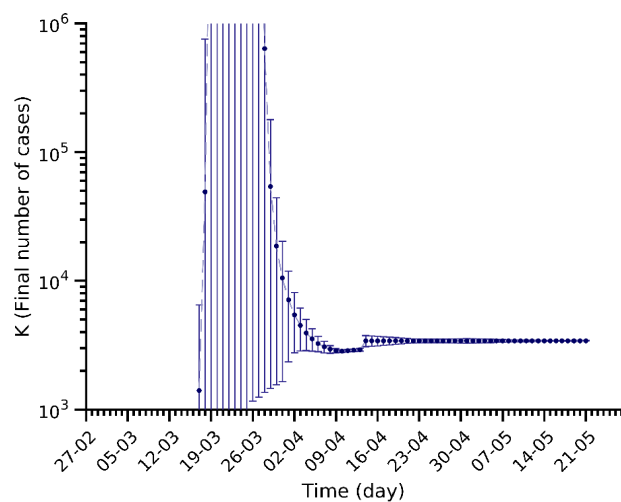
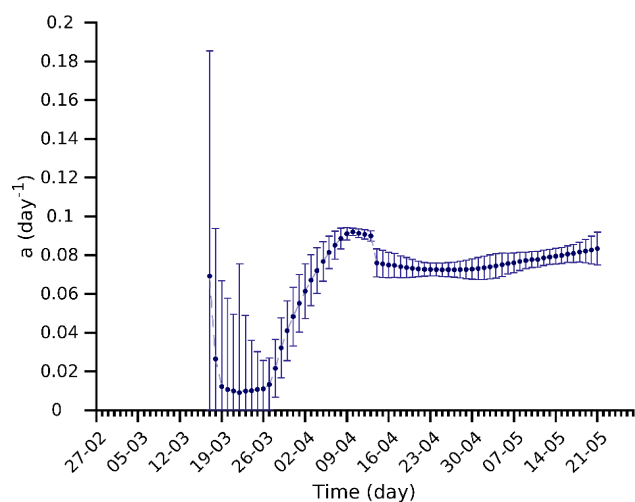
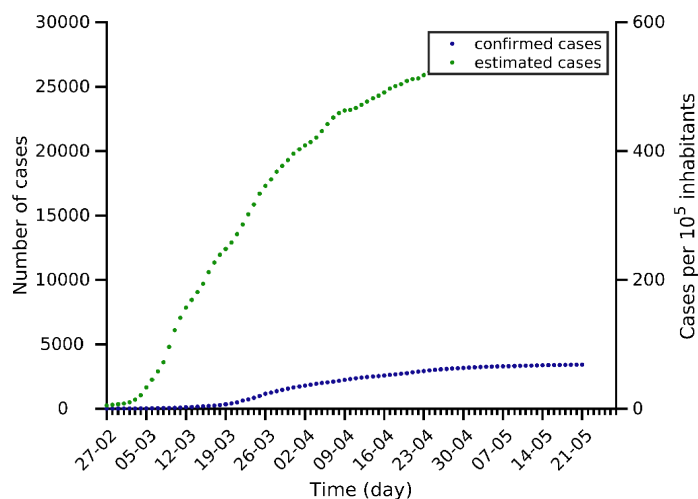
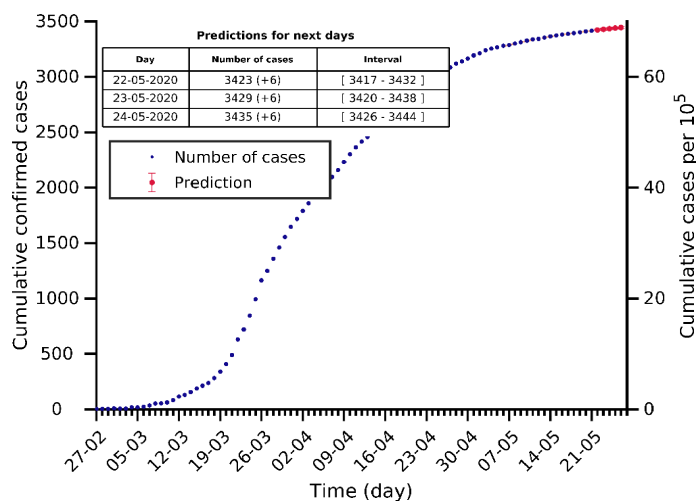
# Puglia 21-05-2020. Population: 4.0M. Current cumulated incidence: 110/10<sup>5</sup>



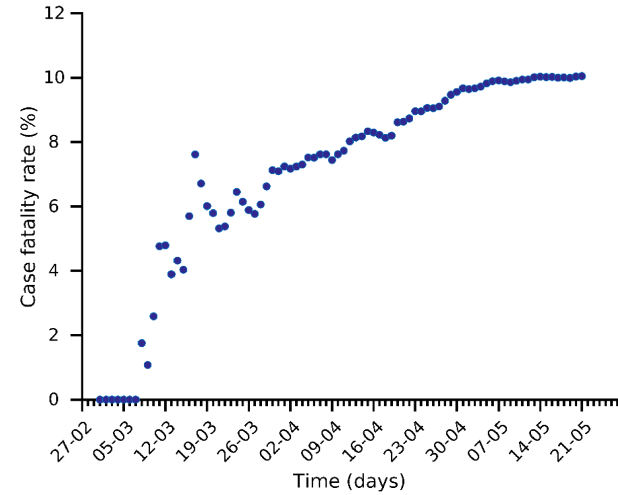
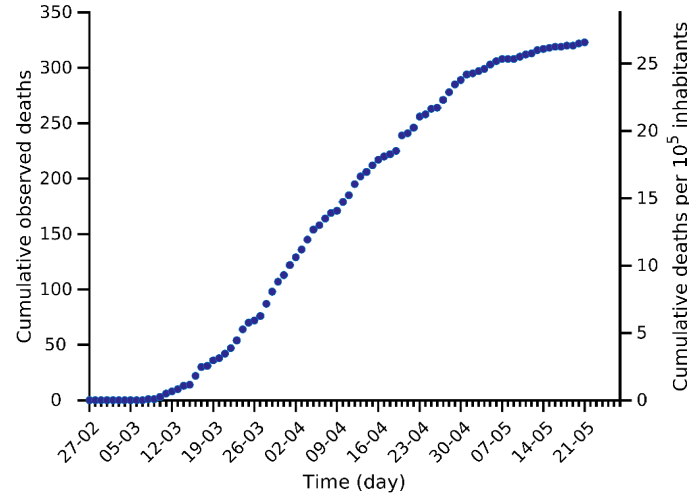
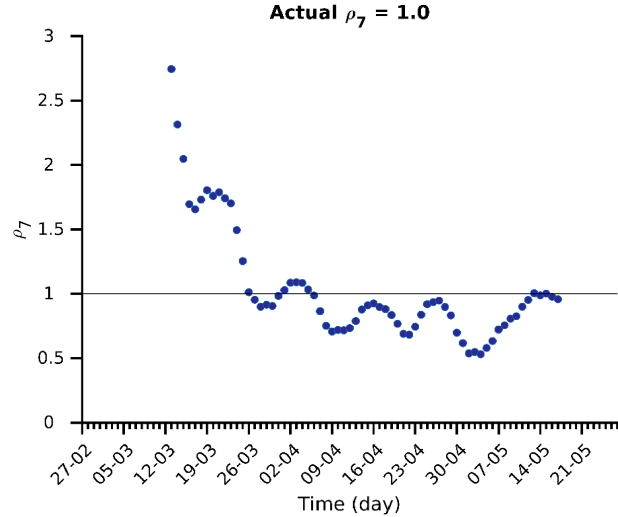
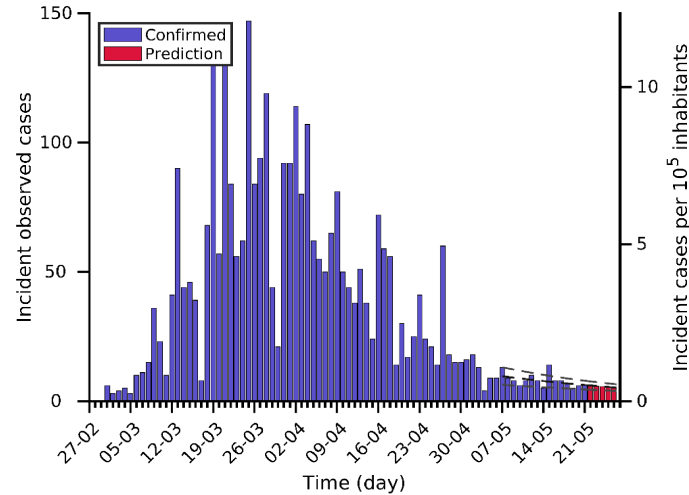
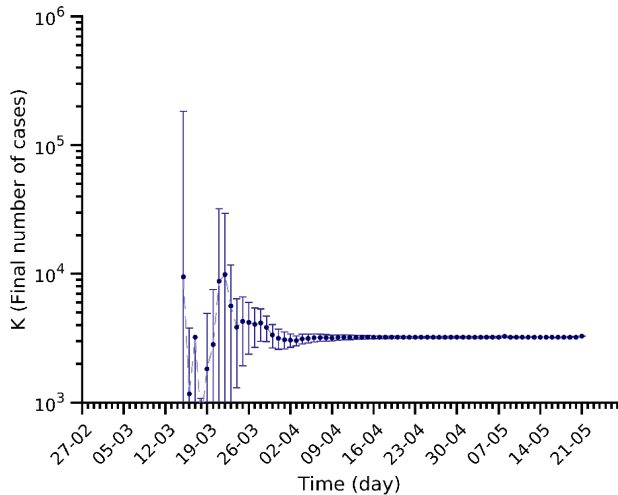
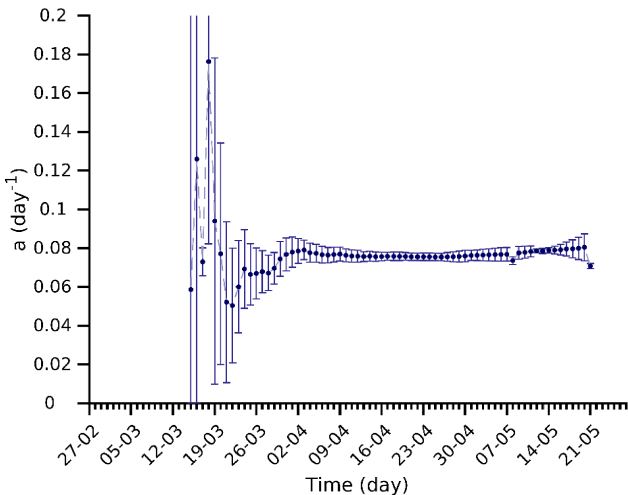
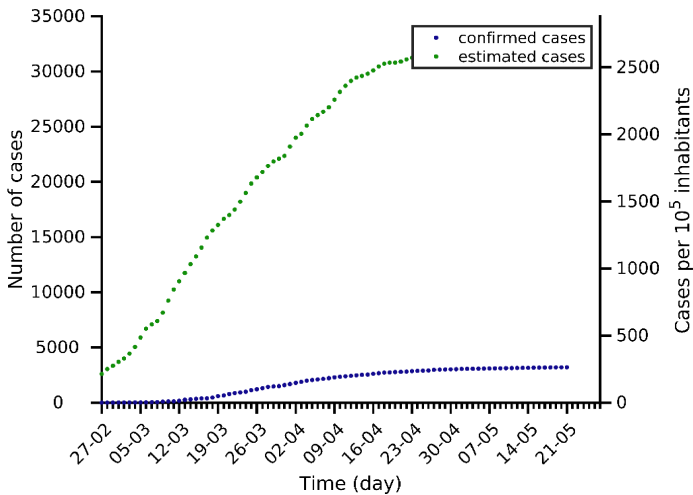
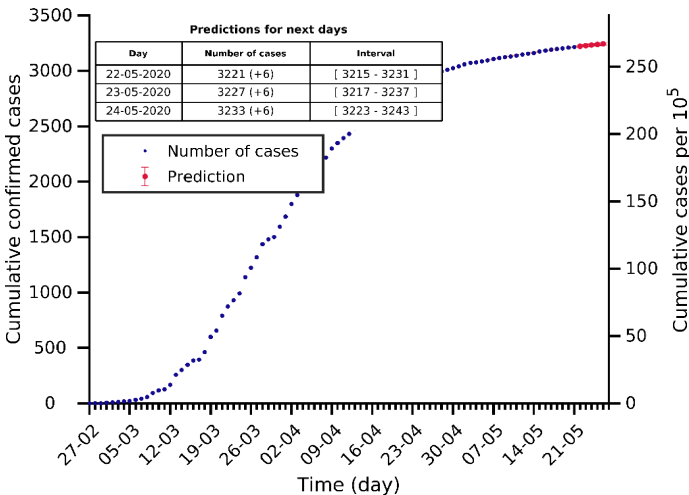
# Trento 21-05-2020. Population: 0.5M. Current cumulated incidence: 814/10<sup>5</sup>



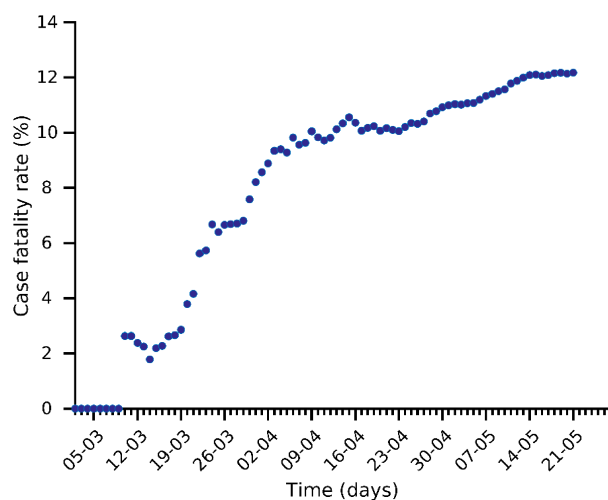
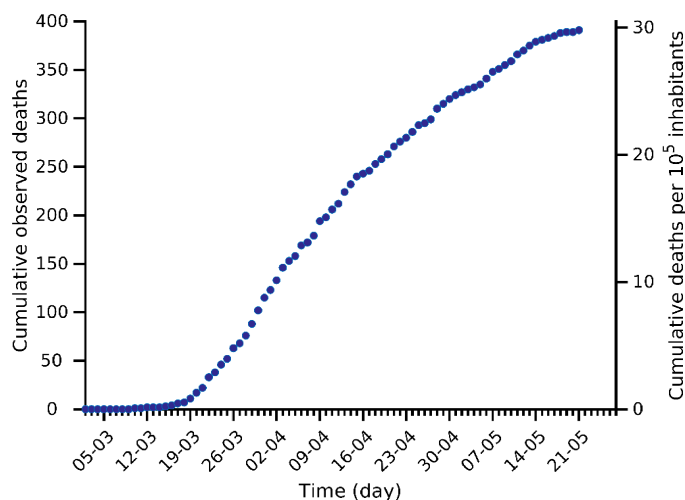
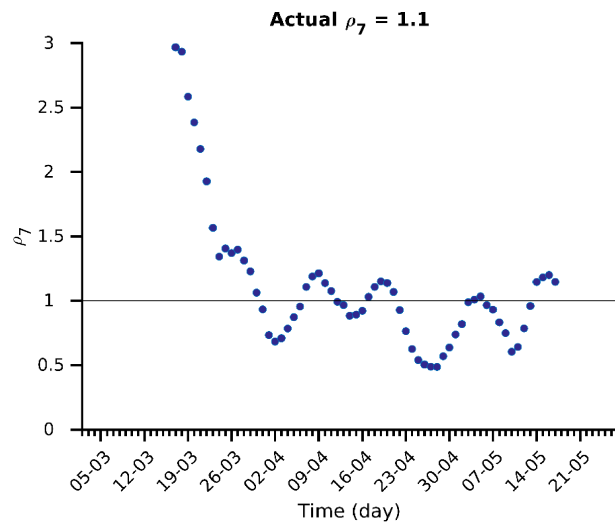
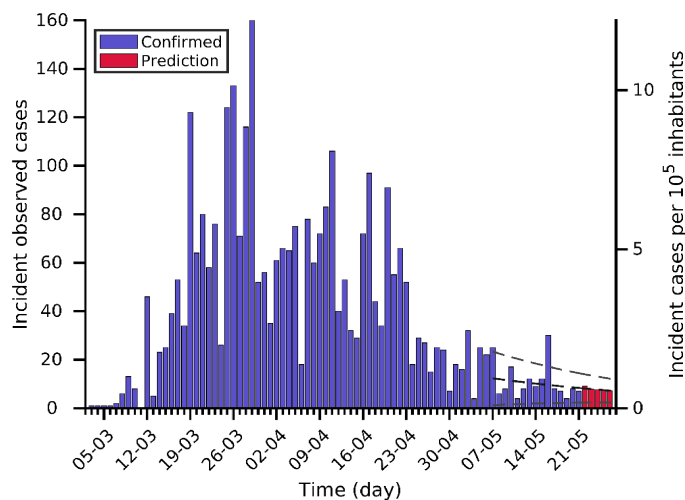
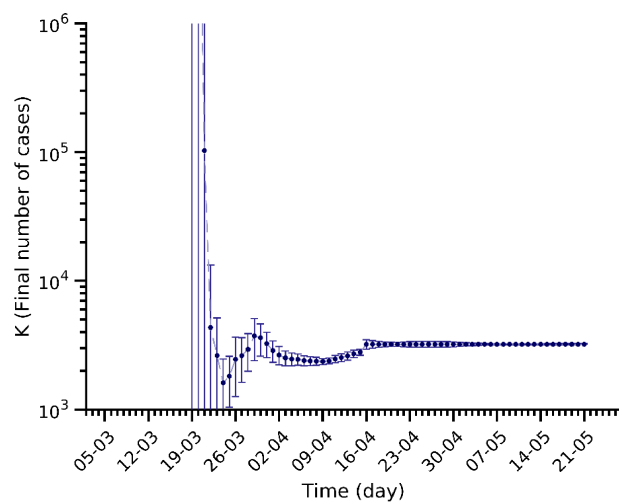
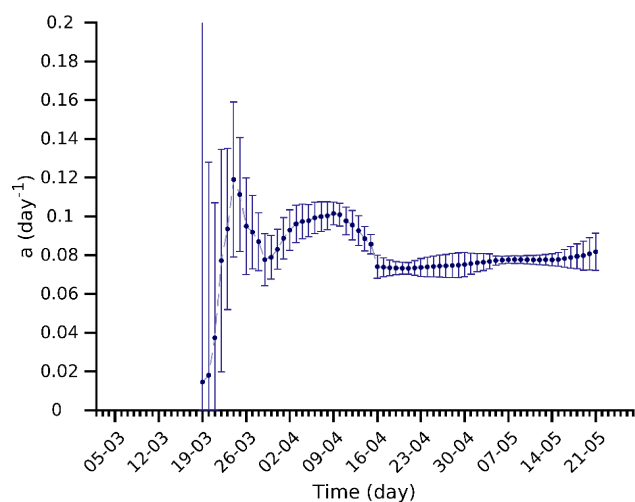
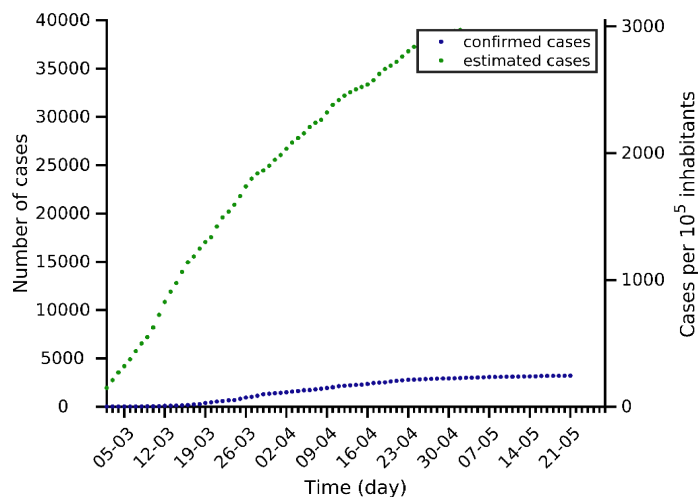
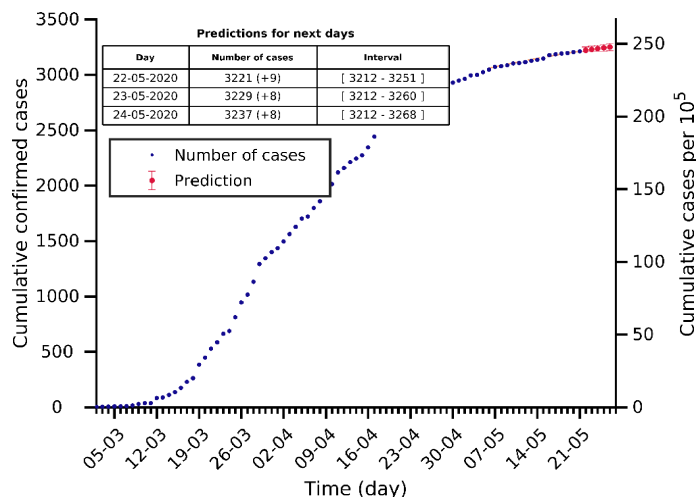
# Sicilia 21-05-2020. Population: 5.0M. Current cumulated incidence: 68/10<sup>5</sup>

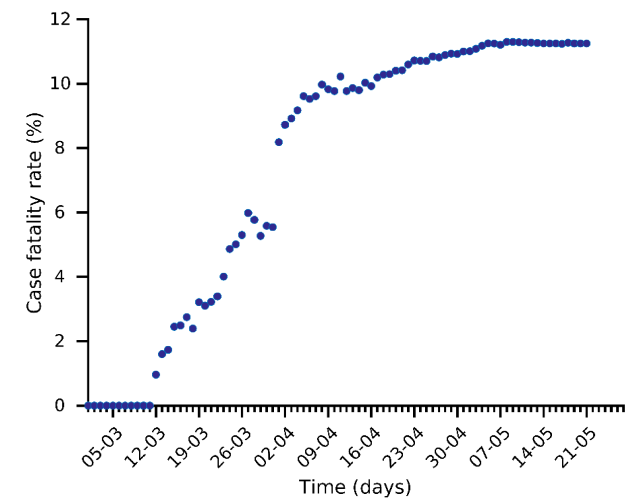
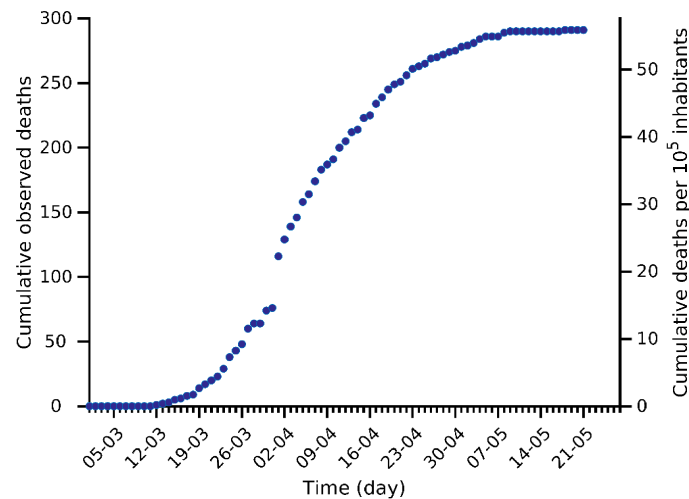
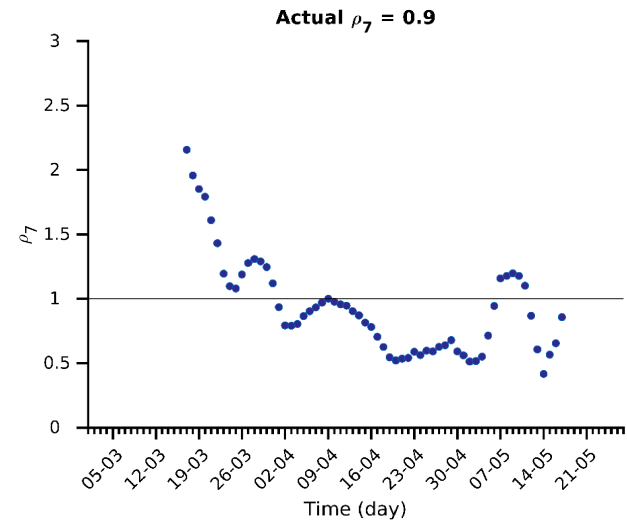
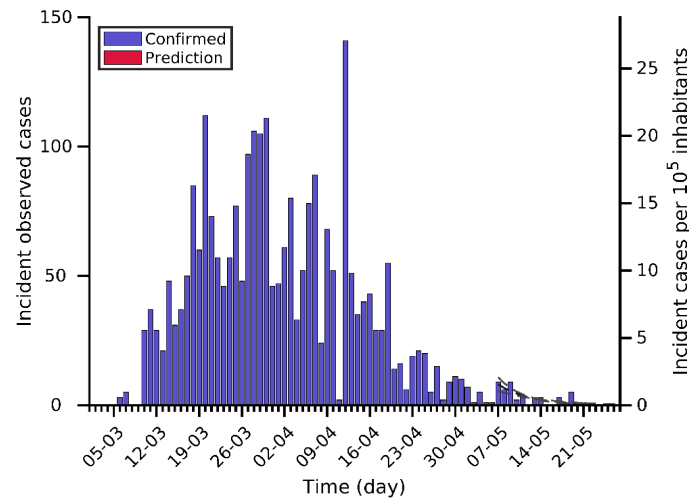
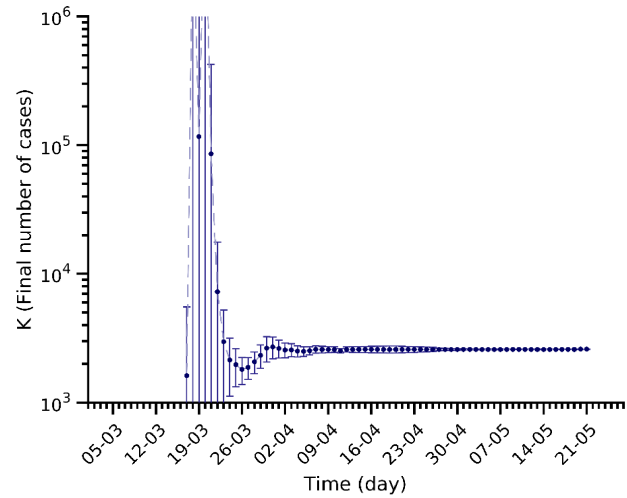
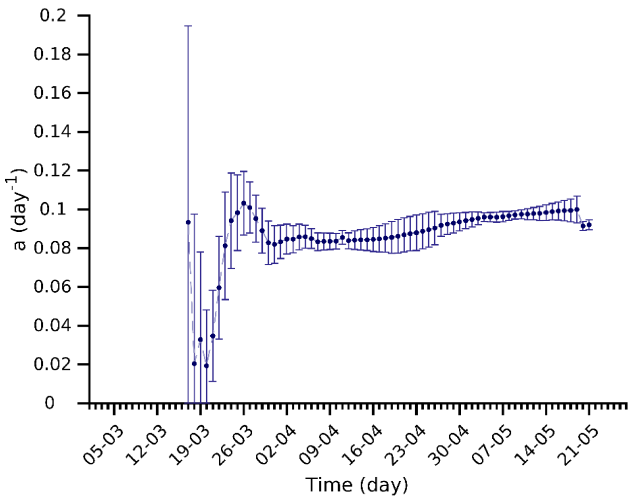
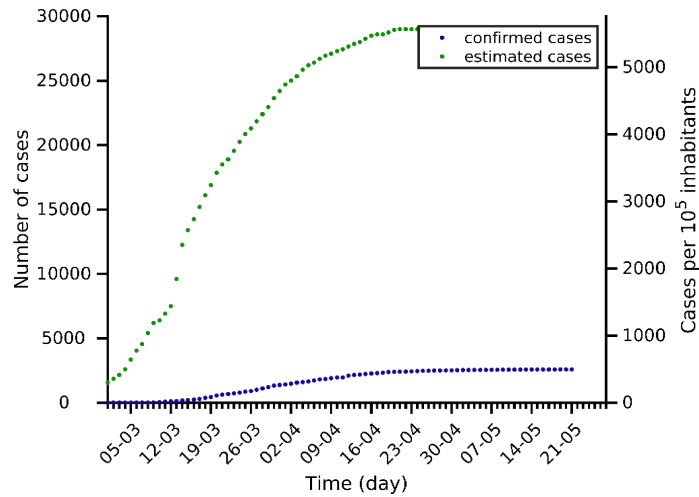
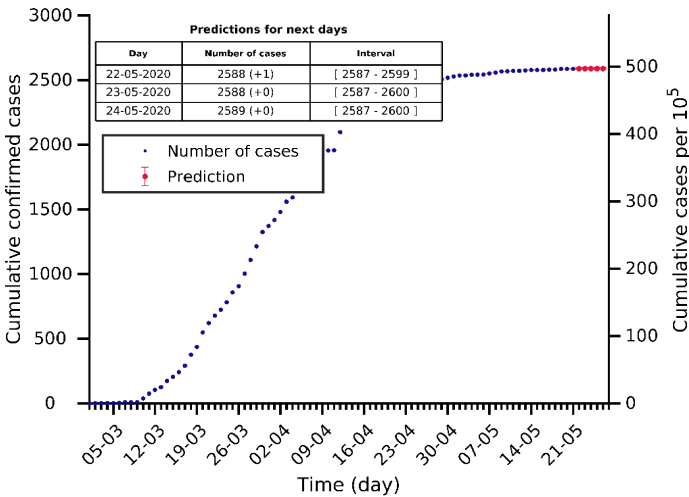


Friuli Venezia Giulia 21-05-2020. Population: 1.2M. Current cumulated incidence: 2



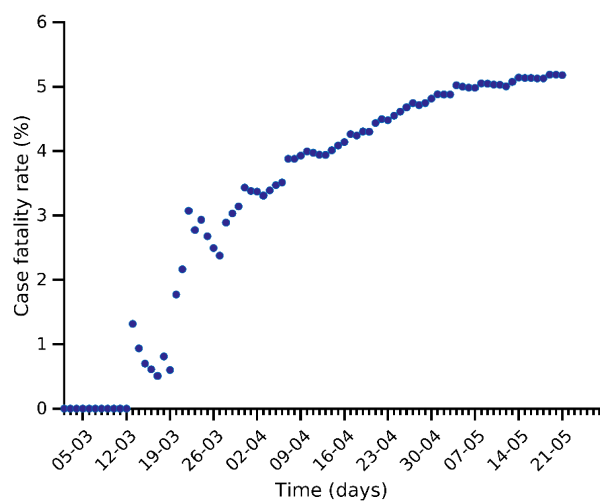
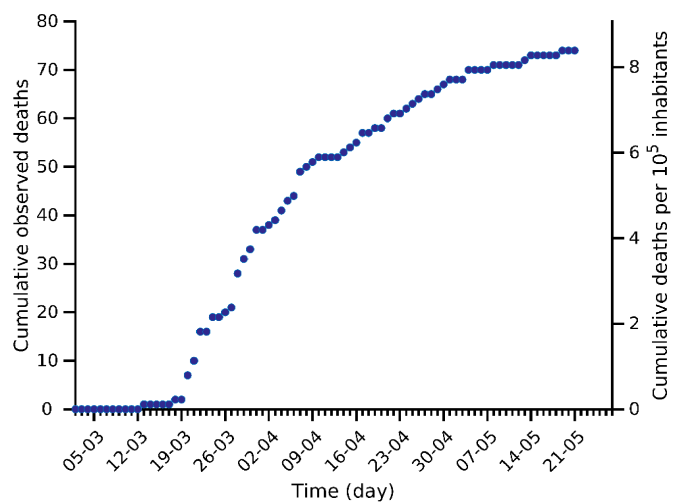
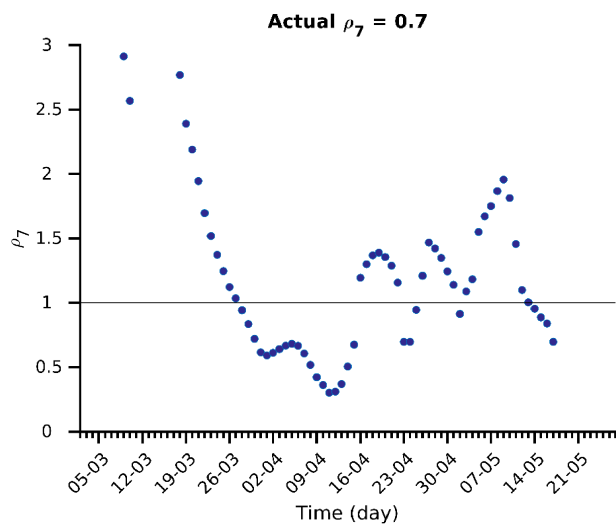
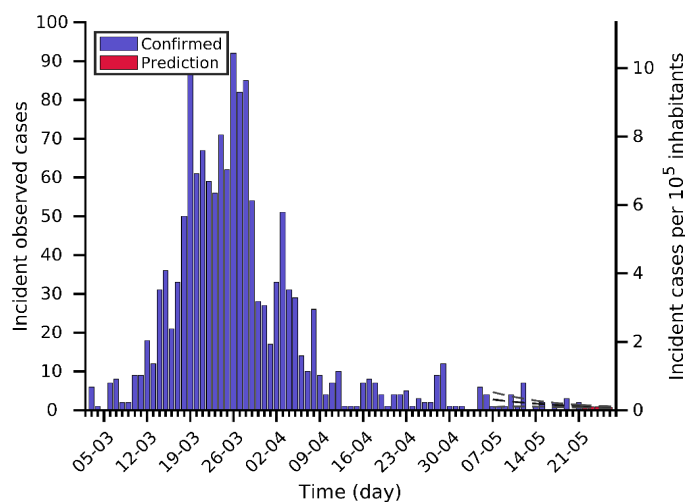
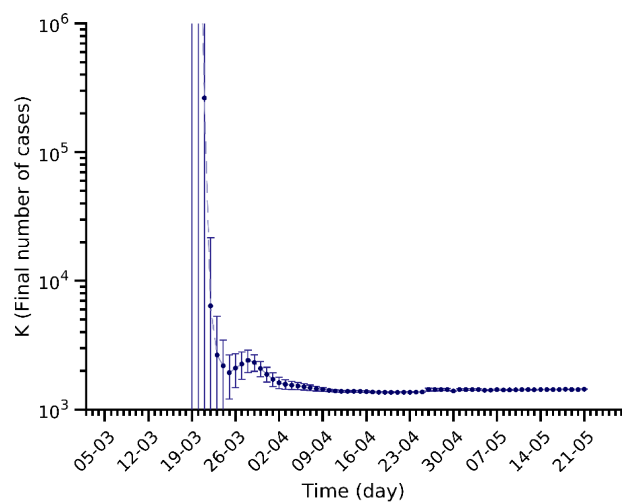
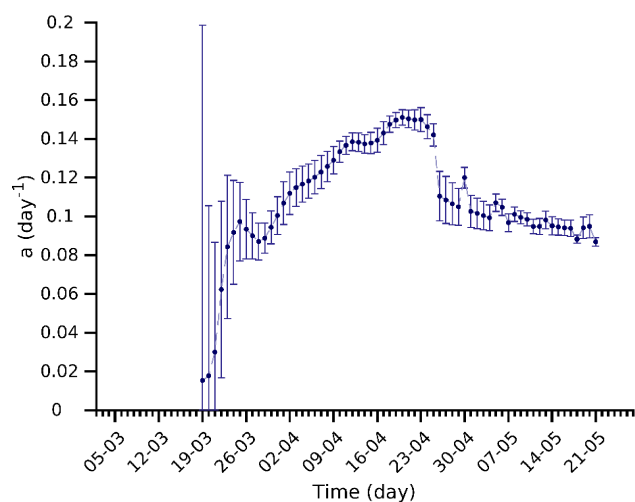
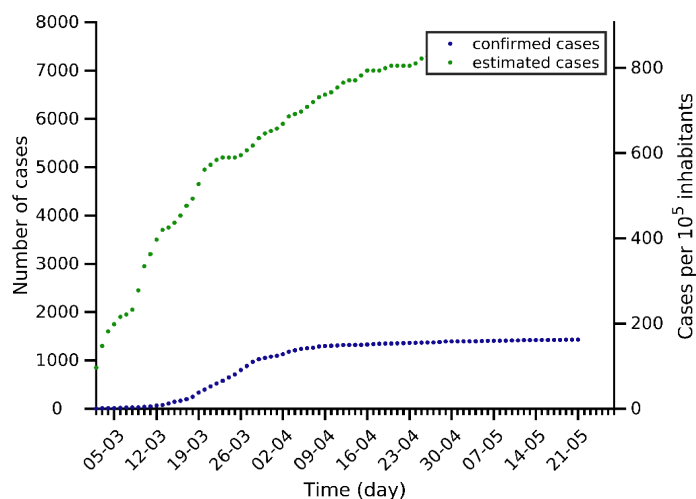
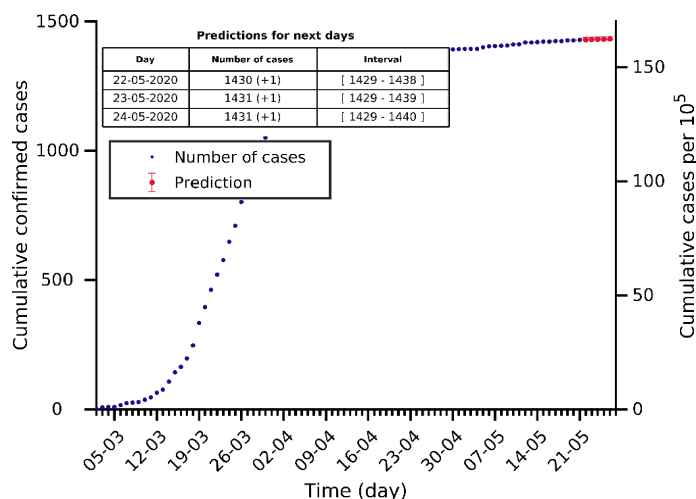
# Abruzzo 21-05-2020. Population: 1.3M. Current cumulated incidence: 245/10<sup>5</sup>



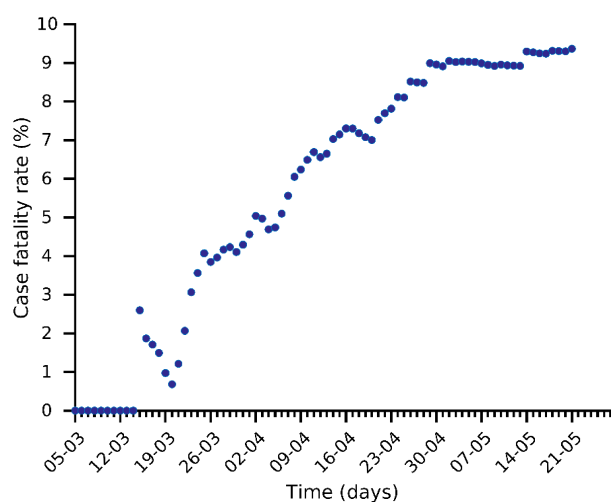
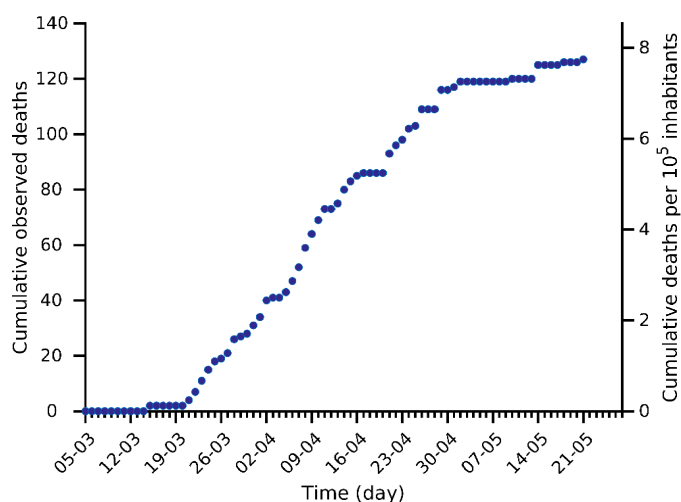
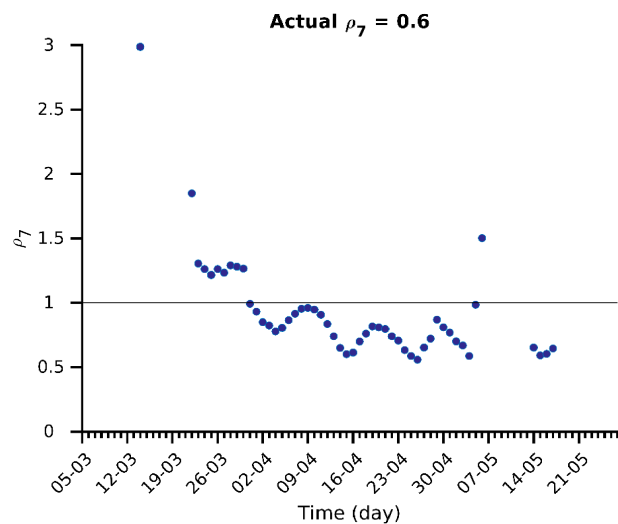
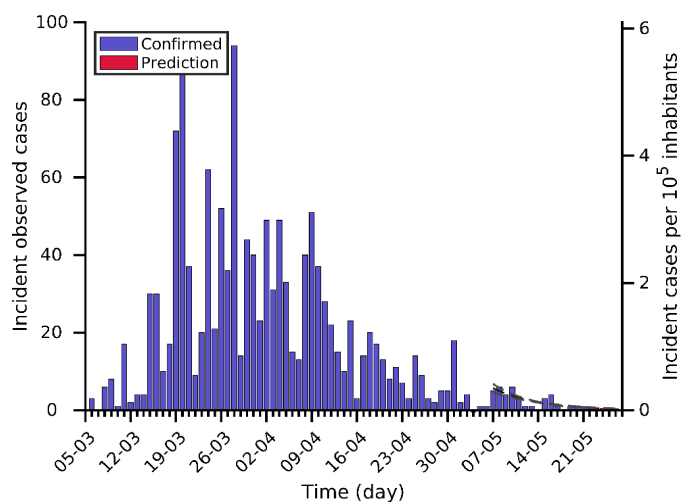
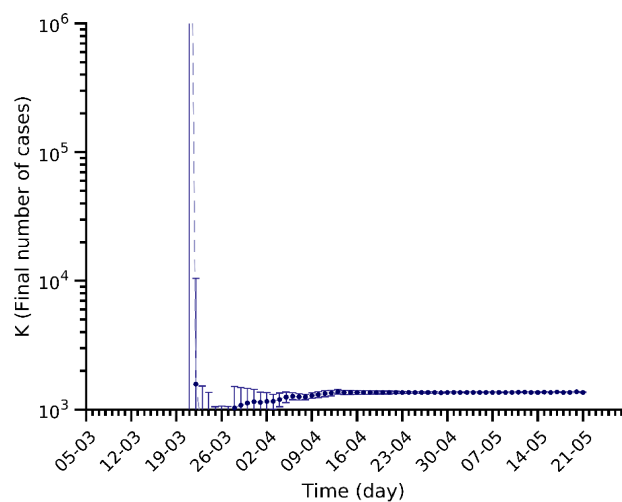
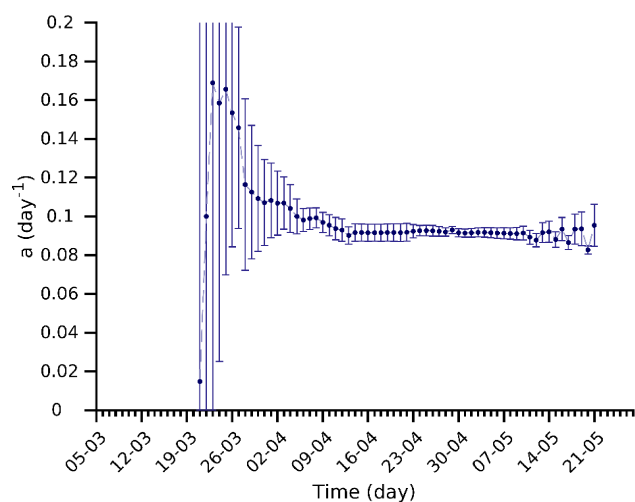
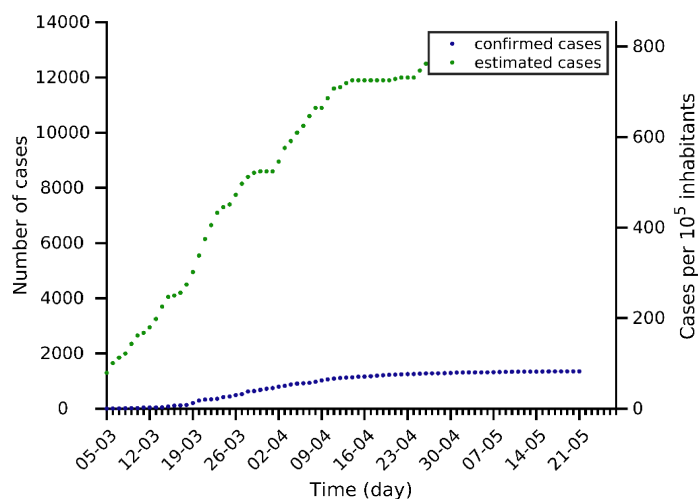
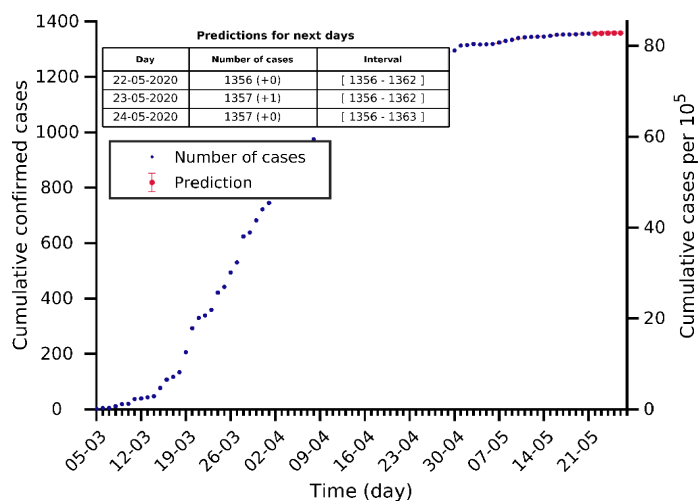




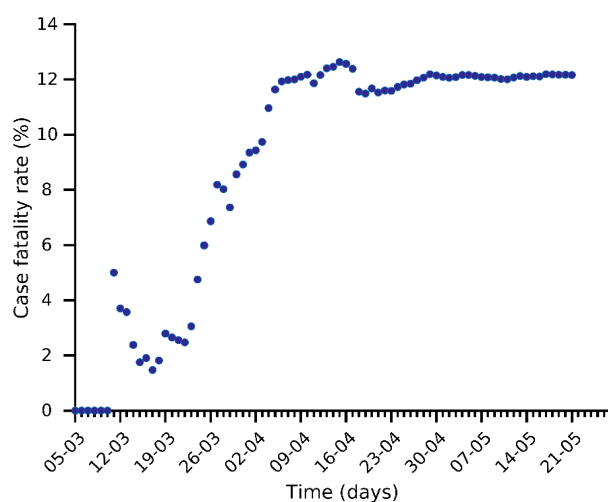
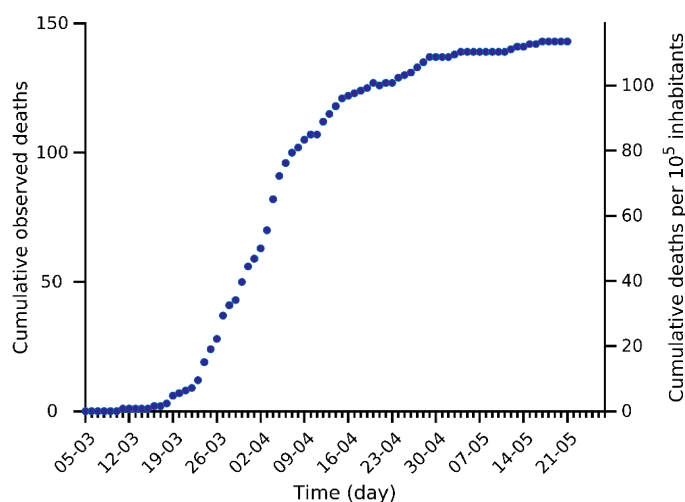
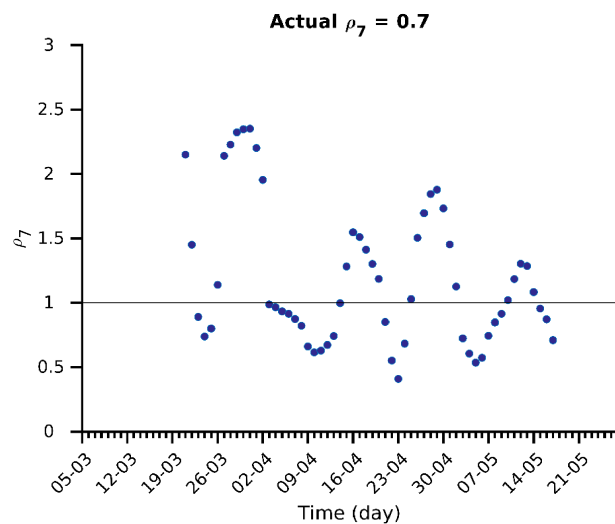
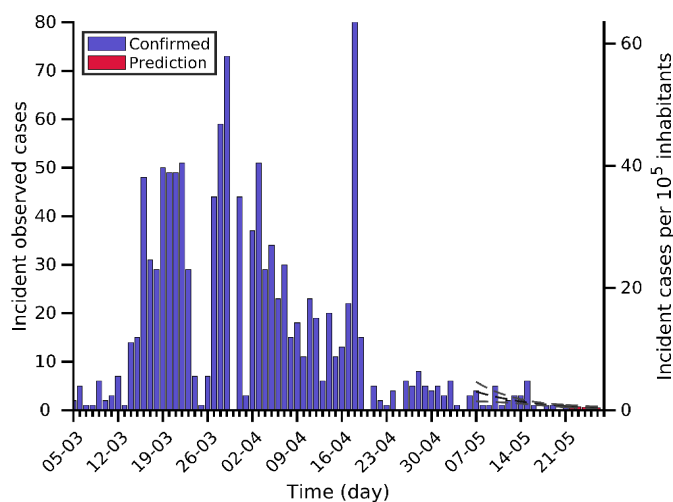
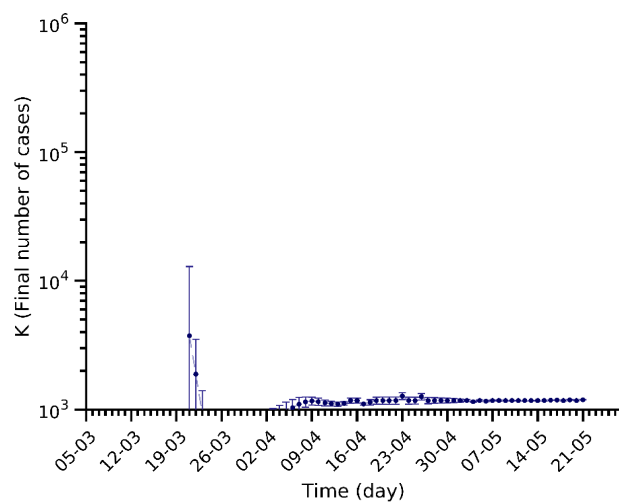
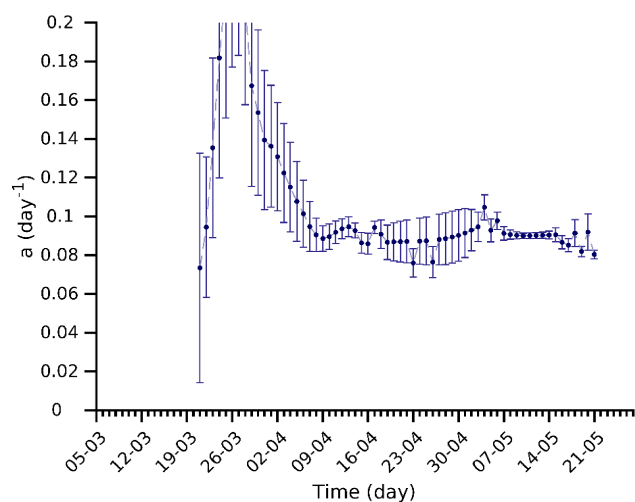
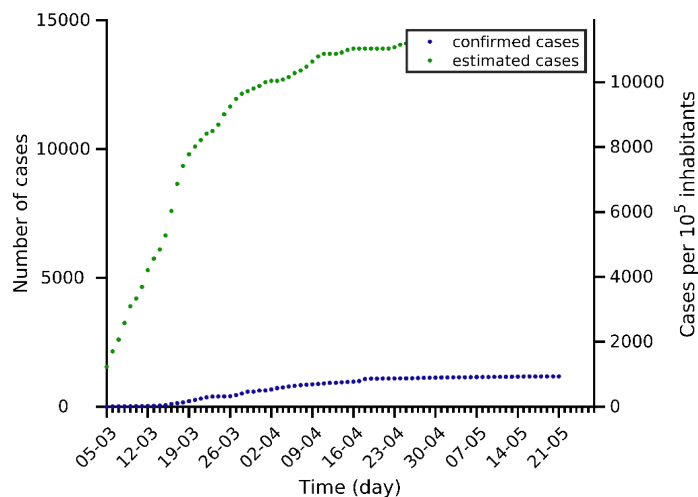
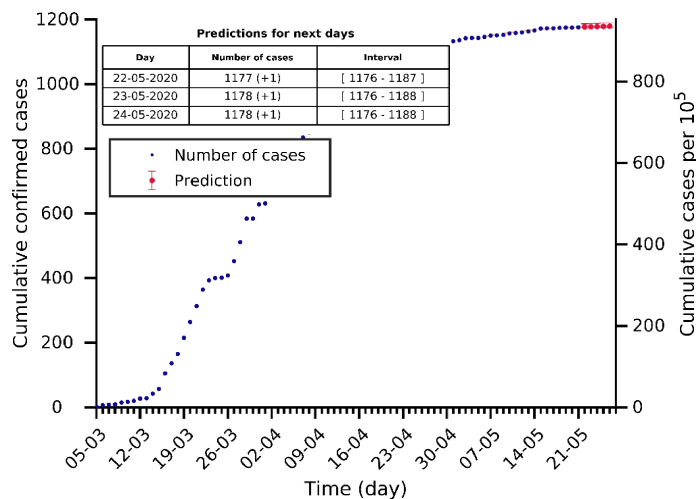
# Umbria 21-05-2020. Population: 0.9M. Current cumulated incidence: 162/10<sup>5</sup>



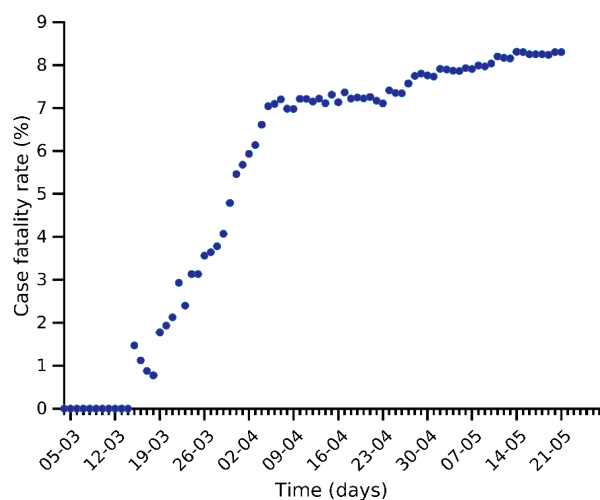
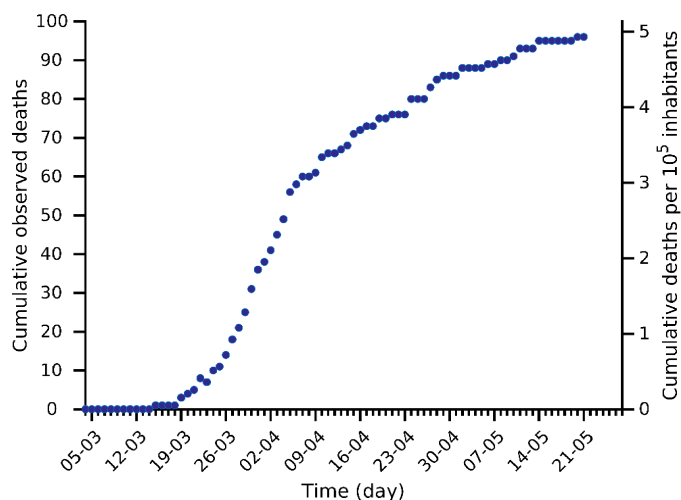
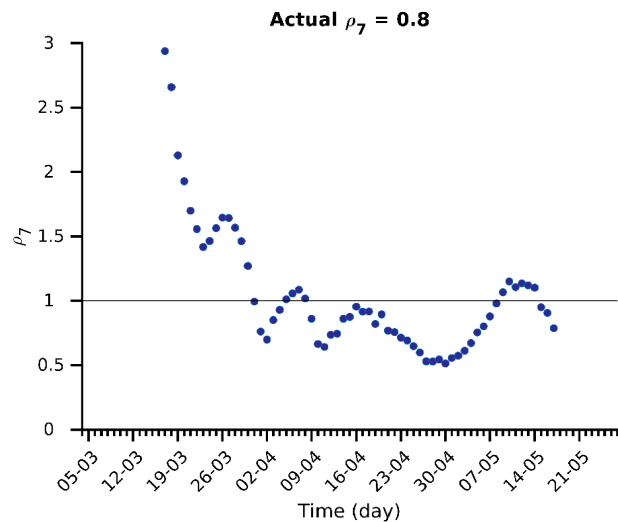
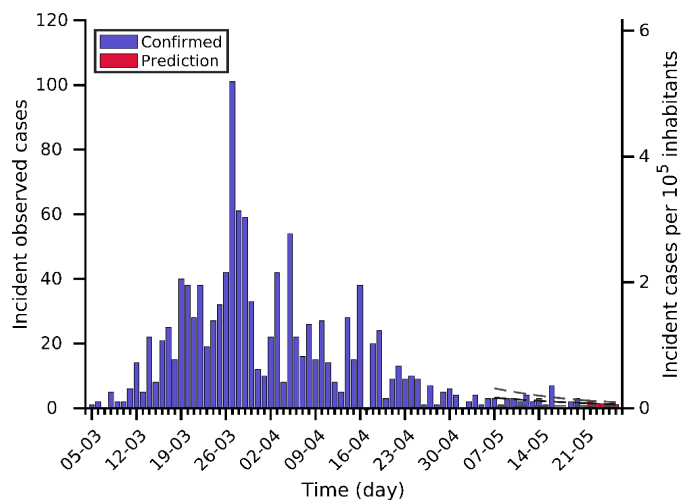
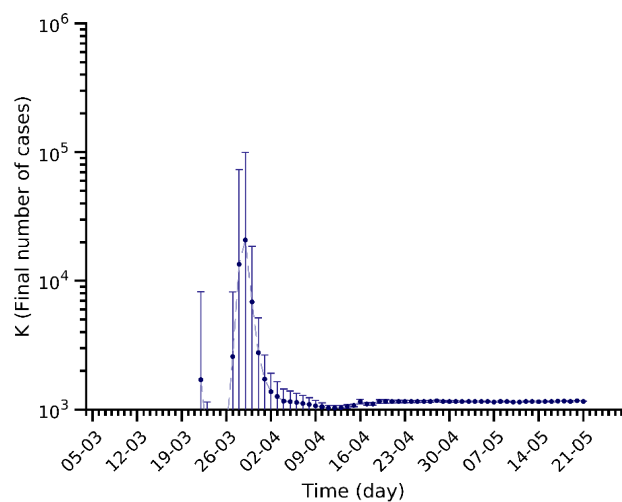
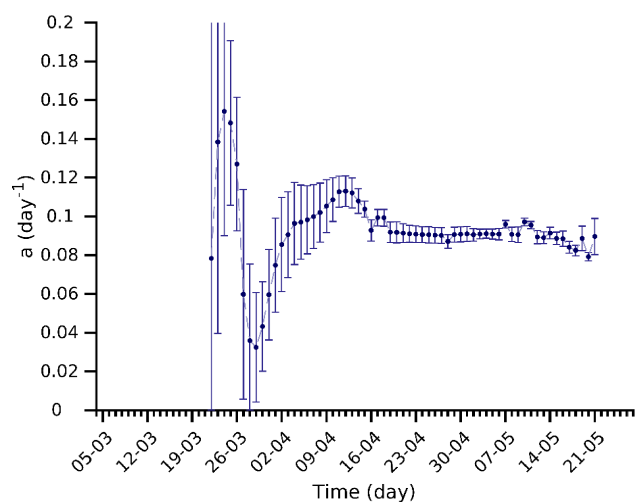
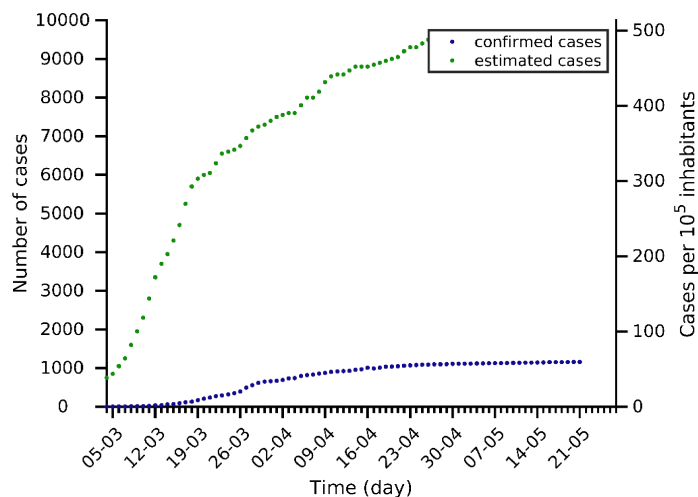
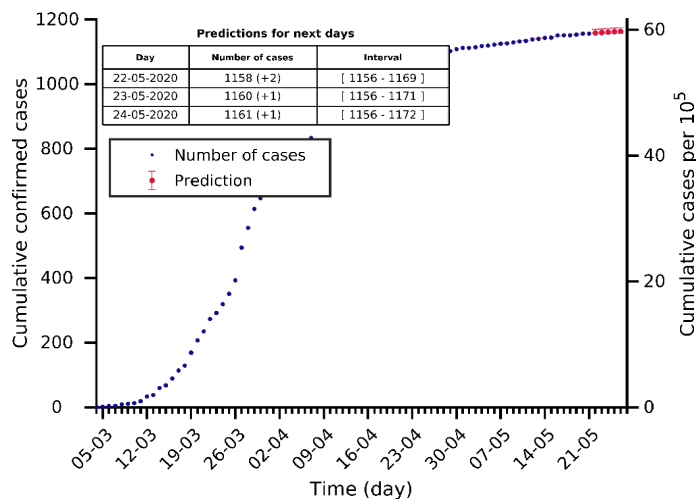
# Sardegna 21-05-2020. Population: 1.6M. Current cumulated incidence: 83/10<sup>5</sup>



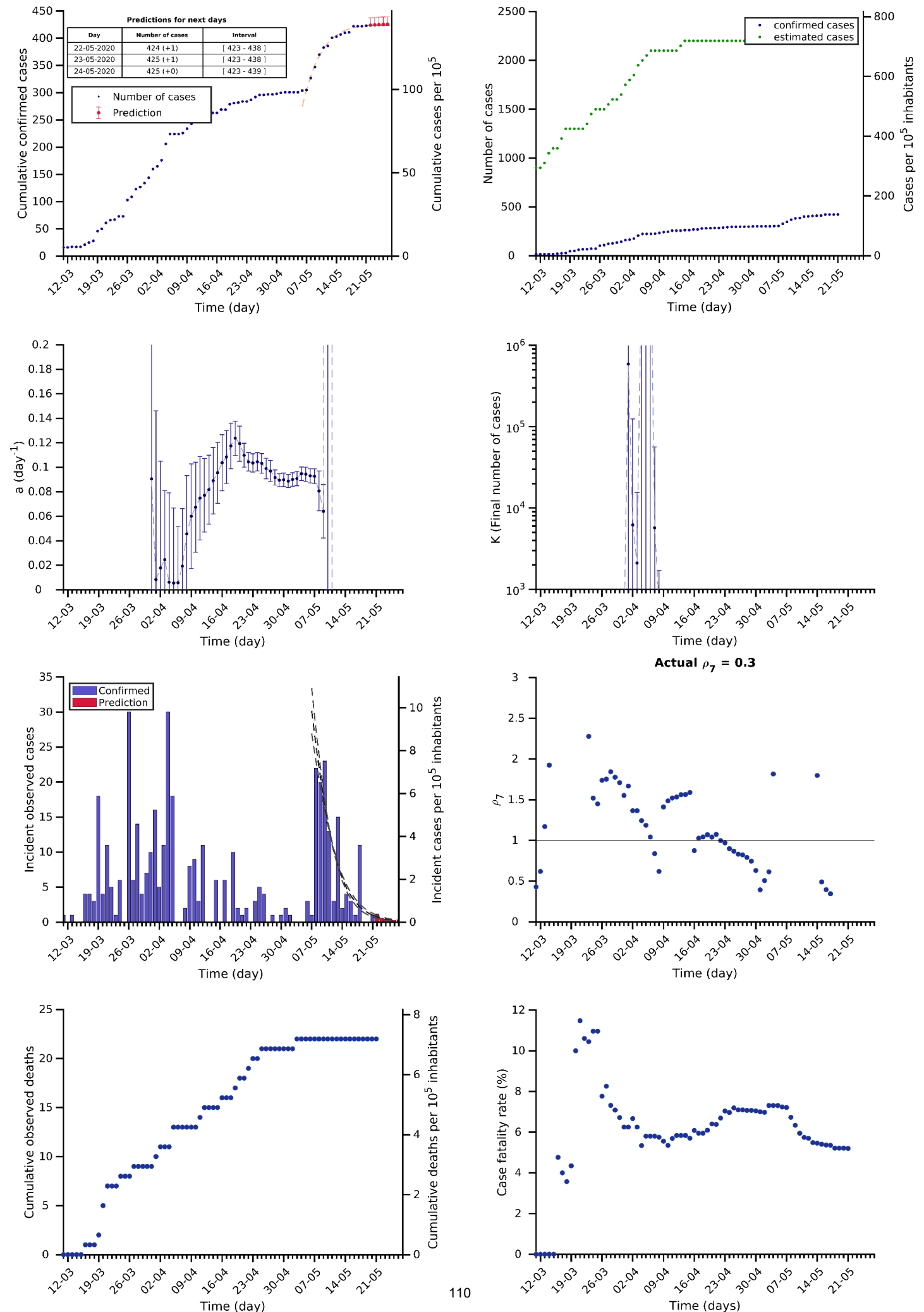
# Valle d'Aosta 21-05-2020. Population: 0.1M. Current cumulated incidence: 933/10<sup>5</sup>



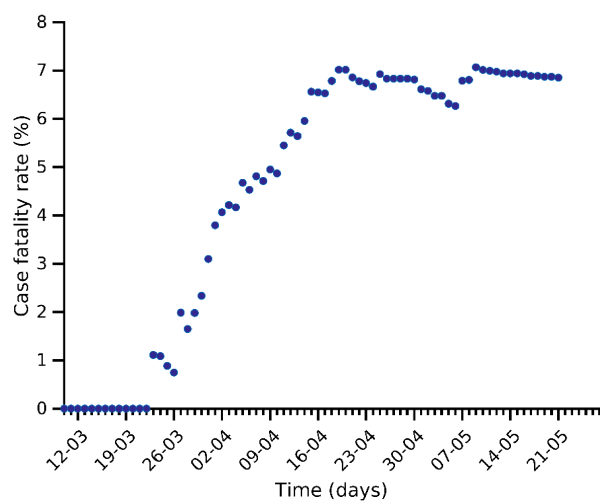
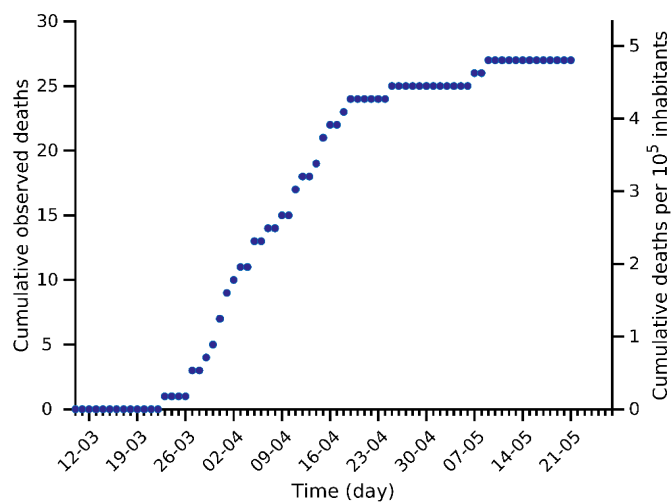
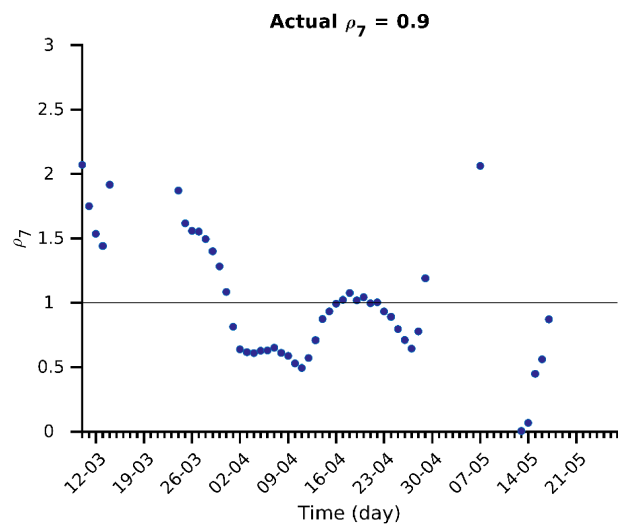
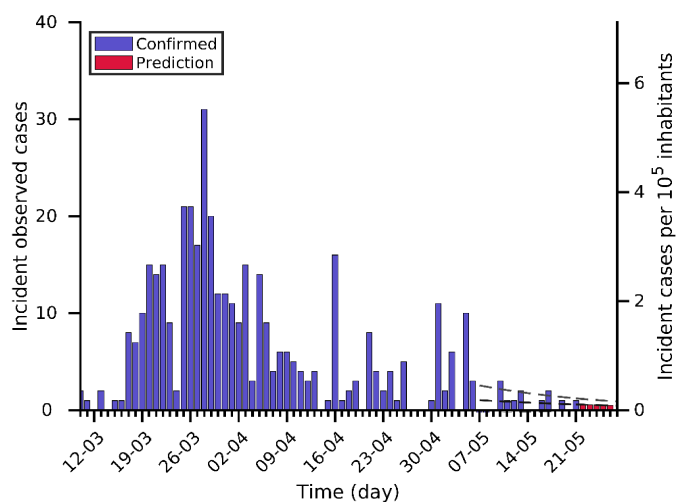
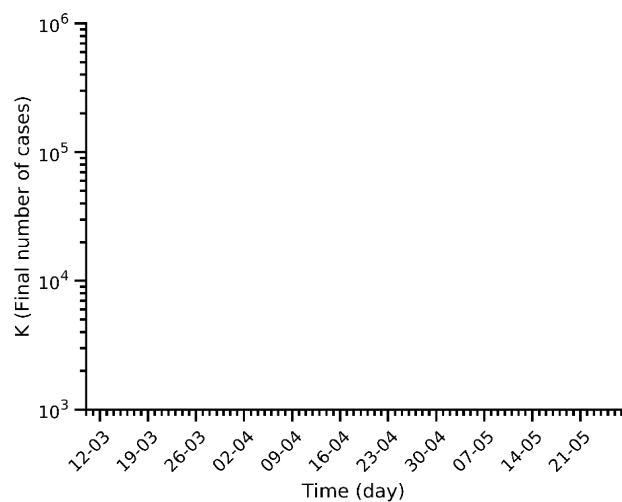
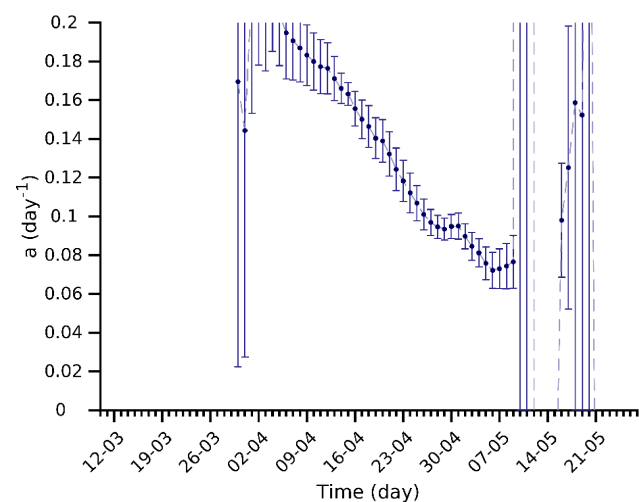
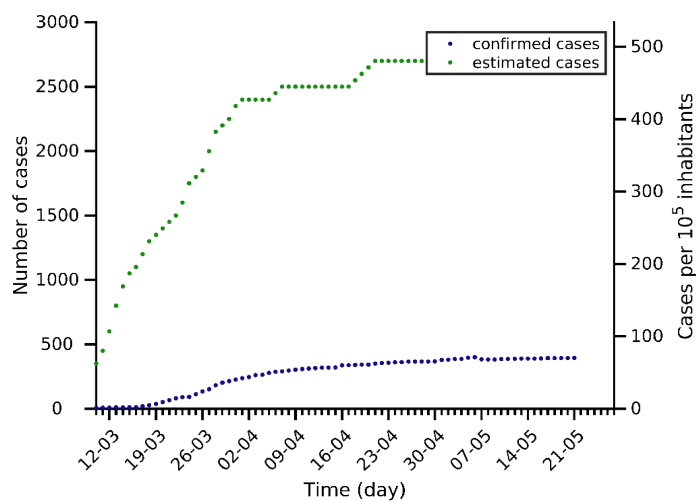
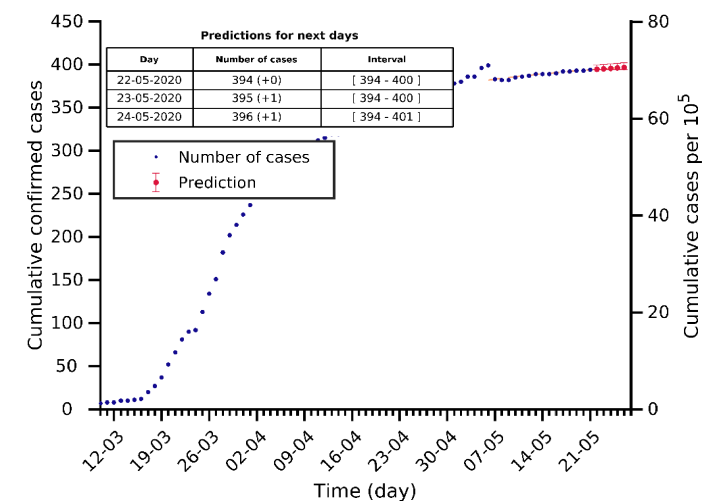
# Calabria 21-05-2020. Population: 1.9M. Current cumulated incidence: 59/10<sup>5</sup>



# Molise 21-05-2020. Population: 0.3M. Current cumulated incidence: 138/10<sup>5</sup>



# Basilicata 21-05-2020. Population: 0.6M. Current cumulated incidence: 70/10<sup>5</sup>



## Methods

## Methods

### **(1) Data source**

Data are daily obtained from World Health Organization (WHO) surveillance reports<sup>1</sup>, from European Centre for Disease Prevention and Control (ECDC)<sup>2</sup> and from Ministerio de Sanidad<sup>3</sup>. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

### **(2) Data processing and plotting**

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓  $\rho$ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ( $t-1$ ):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where  $N_{new}(t)$  is the number of new confirmed cases at day  $t$ .

### **(3) Classification of countries according to their status in the epidemic cycle**

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

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<sup>1</sup> <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

<sup>2</sup> <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

<sup>3</sup> <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>  
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>



#### ***(4) Fitting a mathematical model to data***

Previous studies have shown that Gompertz model<sup>4</sup> correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where  $N(t)$  is the cumulated number of confirmed cases at  $t$  (in days), and  $N_0$  is the number of cumulated cases the day at day  $t_0$ . The model has two parameters:

- ✓  $a$  is the velocity at which specific spreading rate is slowing down;
- ✓  $K$  is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day  $t_0$  is chosen as that one at which  $N(t)$  overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters ( $a$  and  $K$ ) and the  $R^2$  of the fitting. At the initial stages the dynamics is exponential and  $K$  cannot be correctly evaluated. In fact, at this stage the most relevant parameter is  $a$ . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted  $a$  with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted  $K$  with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if  $a > 0.2 \text{ day}^{-1}$ , if  $K > 10^6$  or if the error in  $K$  overpasses  $10^6$ .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

#### ***(5) Using the model for predicting short-term tendencies***

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

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<sup>4</sup> Madden LV. Quantification of disease progression. *Protection Ecology* 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days<sup>5</sup>;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

### ***(6) Estimating non-diagnosed cases***

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors<sup>6</sup> in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

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<sup>5</sup> At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

<sup>6</sup> Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3